APPENDIX E

SLOPE STABILITY ANALYSIS DONE BY USBR

IN-DELTA STORAGE PROGRAM
ENGINEERING INVESTIGATIONS
DRAFT REPORT

November 19, 2001

Engineer Review Board
December 11-13, 2001

Plots from SlopeW Analysis
done by US Bureau of Reclamation

Table 3. Material Properties

Material	Weight γ, lb/ft^3		Unconsolidated Undrained Strength		Consolidated Drained Strength		Consolidated Undrained Strength	
	Wet	Sat.	c lb/ft^2	φ, degrees	c', lb/ft^2	φ', degrees	c', lb/ft^2	φ', degrees
New fill	110 (120)	120 [115]	0	30	0 (0) [0]	30 (34) [35]	0	30
Existing fill, sand	(110)	110	0	30	0 (0)	30 (32)	0	30
Existing fill, sand with clay and peat	(110) [105] {115}	110 {130}	0 (135)	30 (12)	0 (80) [0] {0}	30 (27) [35] {30}	0	30
Peat under dam @ centerline		70 [70] {83}	50-1500 (135) [100-300]	0 (12) [0]	50 (50) [50] {50}	28 (28) [30] {19}	100	15
Free field peat	(70)	70	250 (135) [100-300]	0 (12)	50 (50)	26 (26)	100	15
Deep sand	-	125 [125] {125}	-	-	0 [0] {0}	36 [37] {40}	0	36
Gray fat clay	-	85	200-300 [200-300]	0 [0]	0 [100]	25 [30]	100	30

() values used by URS Greiner Woodward Clyde in the 2000 report.
[] values used by Harding and Lawson in the 1989 study.
{} values used by State of California in the 1990 Levee Rehabilitation study

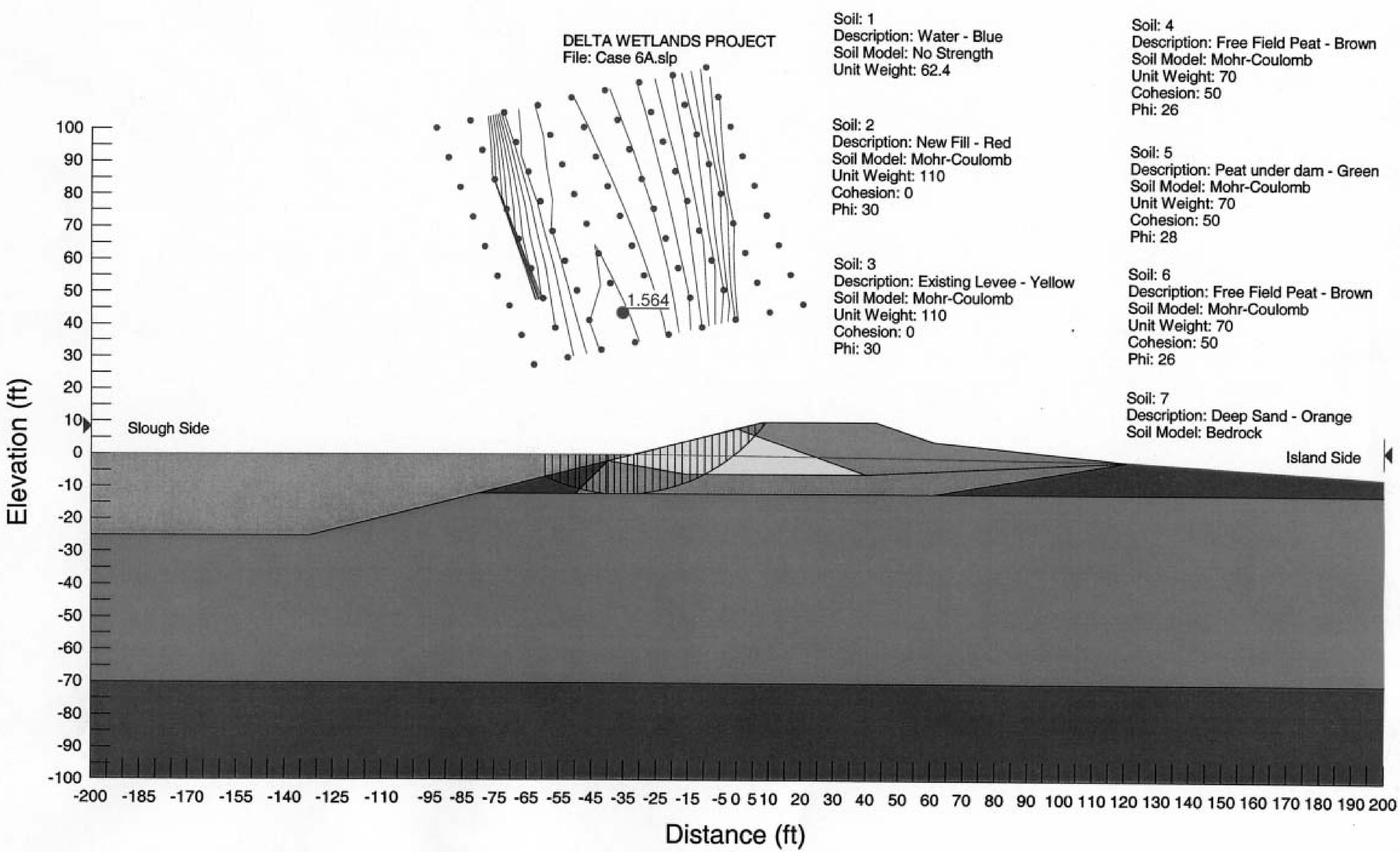
b. Steady-state Condition with Sliding Towards River/slough. - The analyses done for DW and confirmed in this analysis (as shown on Table x), indicate that a potential sliding failure into the river/sloughs exist for the steady-state condition. The factors of safety are below both the recommended dam and levee design criteria. This potential problem primarily exists where the channel is deep. The embankments with the existing slopes and a full reservoir have the potential to slide into the channels, which could cause unacceptable environmental damage, damage to floating structures, damage to adjacent levees, potential loss of life, and require expensive dredging to clean up. Loss of the reservoir may not occur because of the width of the embankments. The proposed modifications to the embankments by DW do not include modifying the river/slough side slopes. The costs for repairs and clean up of the slide mass would need to be accounted for in the overall cost of the DW proposed project.

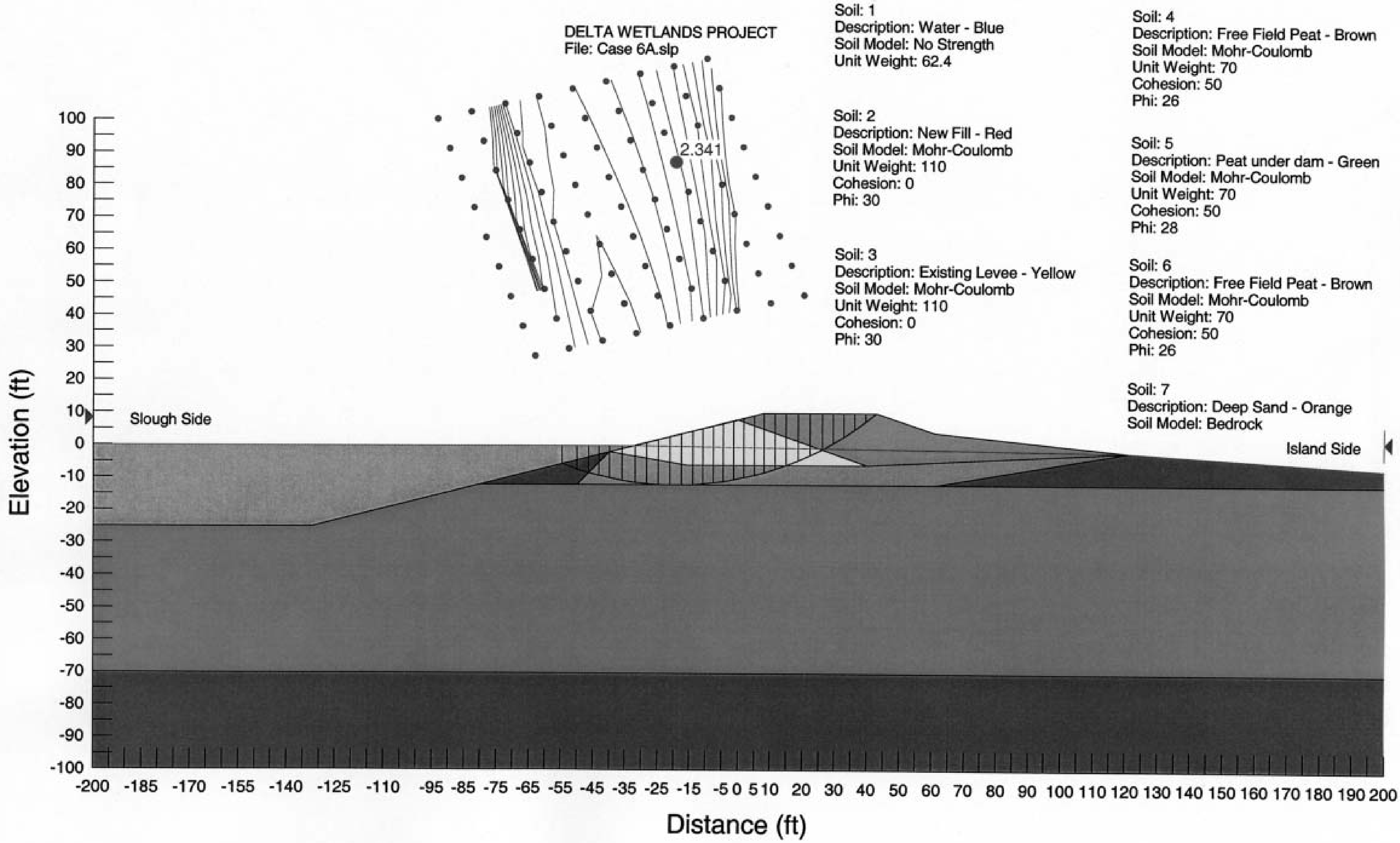
DWR/BOR recommends that the slopes of the embankments on the river/slough side be flattened during initial construction to increase the factor of safety against a sliding failure. Careful construction control will be required to minimize environmental impact. Flattening of the slope will require the centerline of the embankments to be shifted towards the island side and increase overall fill quantities. However, material excavated can be used in the construction of the new fill. The required slopes needed to increase the factor of safety to above the design criteria will vary depending upon depth of channel, thickness of peat, strength of peat, and height of embankments. Table x shows the DWR/BOR analysis for this loading condition with two variations of embankment height and peat thickness and varying peat strengths. Based on this analysis, it is recommended that a 4:1 slope be required on the river/slough side. This slope was assumed to be an average of what will actually be required with some slopes being steeper and some needing to be flatter. During final design more specific analyses should be done to determine actual slopes needed based on additional topographic data.

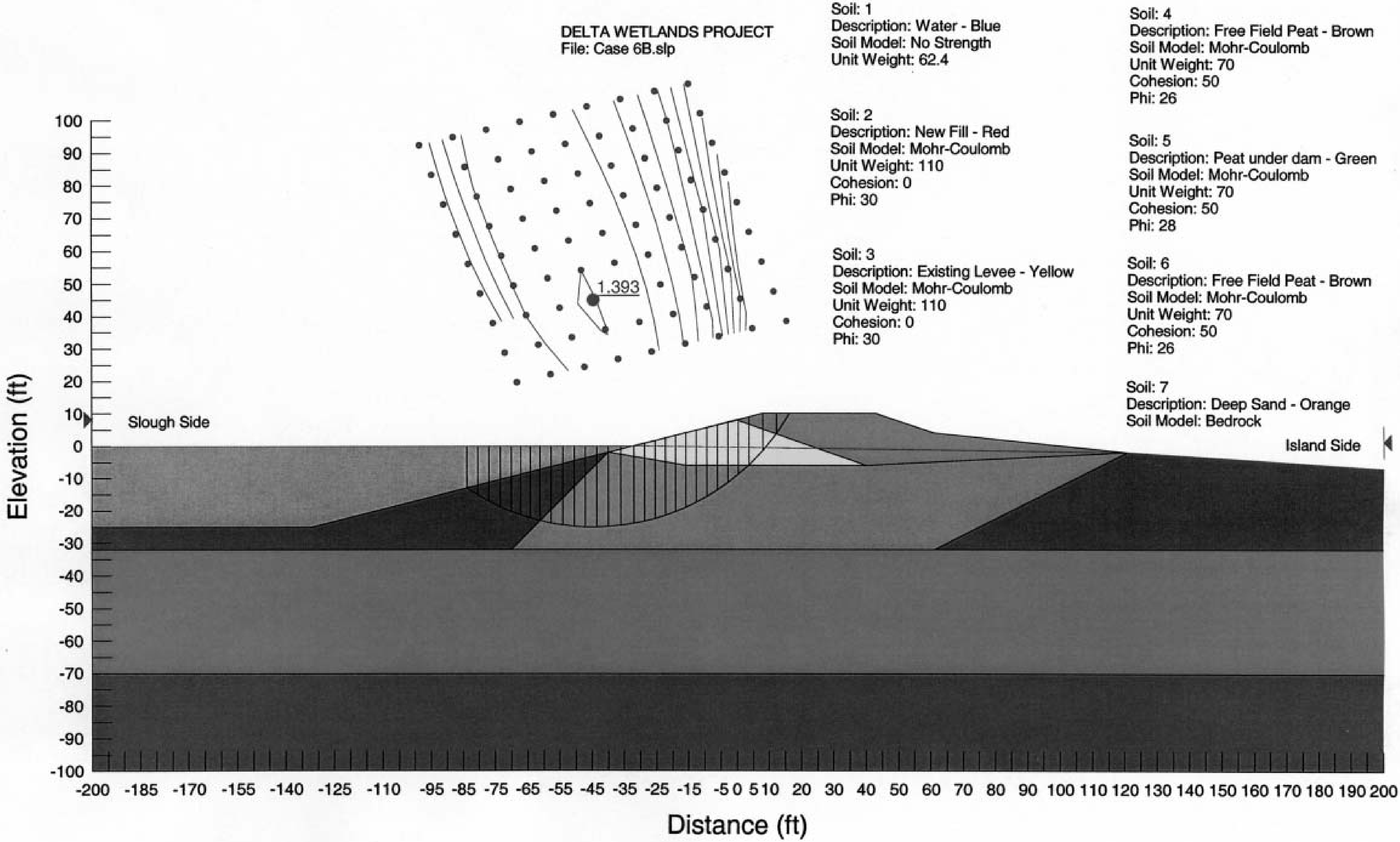
Table x. DWR/BOR Factors of Safety for Steady-state Condition and Sliding Towards River/Slough

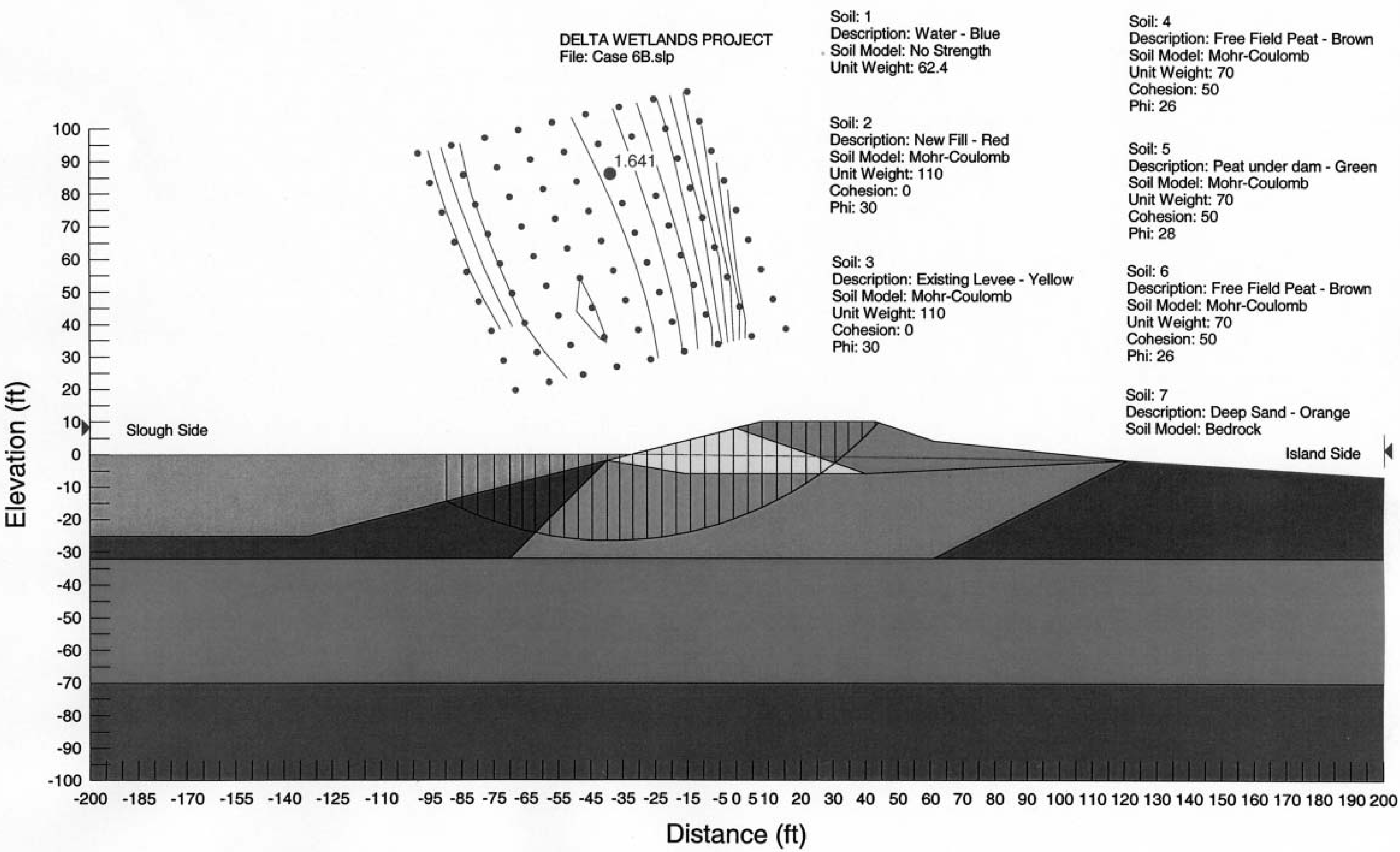
	Slope (H:V) above Elevation 0	Peat Strength free field//under dam//cohesion (phi//phi//psf)	Factor of Safety* 10' embankment				Factor of Safety* 18' embankment			
			10' peat		30' peat		10' peat		30' peat	
			A	A	B	B	C	C	D	D
1	2:1	30//0	.95	1.55	.95		1.24		1.14	
2	3:1	30//0	1.13		1.04		1.37		1.19	
3	4:1	30//0	1.33	1.54	1.13		1.51		1.24	
4	2:1	26//28//50	1.19	1.68	1.16	1.28	1.43	1.65	1.25	1.31
5	3:1	26//28//50	1.31	1.88	1.24	1.39	1.51	1.79	1.29	1.35
Plt # → 6	4:1	26//28//50	1.56	2.34	1.39	1.64	1.73	2.29	1.43	1.59
7	2:1	15//19//100	1.2		1.08		1.36		1.1	
8	3:1	15//19//100	1.28		1.12		1.43		1.17	
9	4:1	15//19//100	1.46		1.17		1.53		1.22	

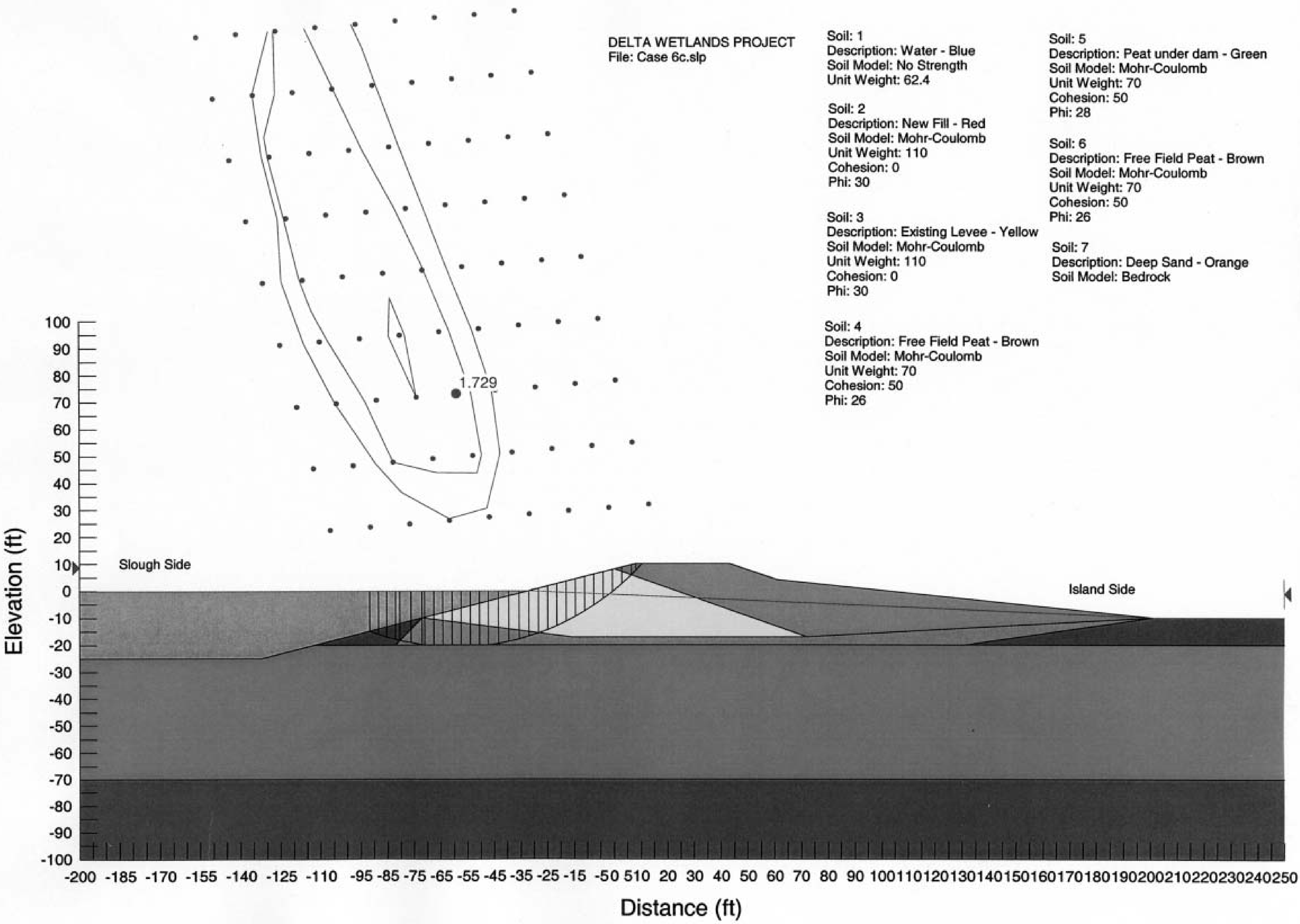
* Where there are two values reported, the first value is the factor of safety that takes out only a portion of the crest and the other factor of safety is for a sliding surface that includes the entire crest.


DELTA WETLANDS PROJECT
File: Case 6A.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.564
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)

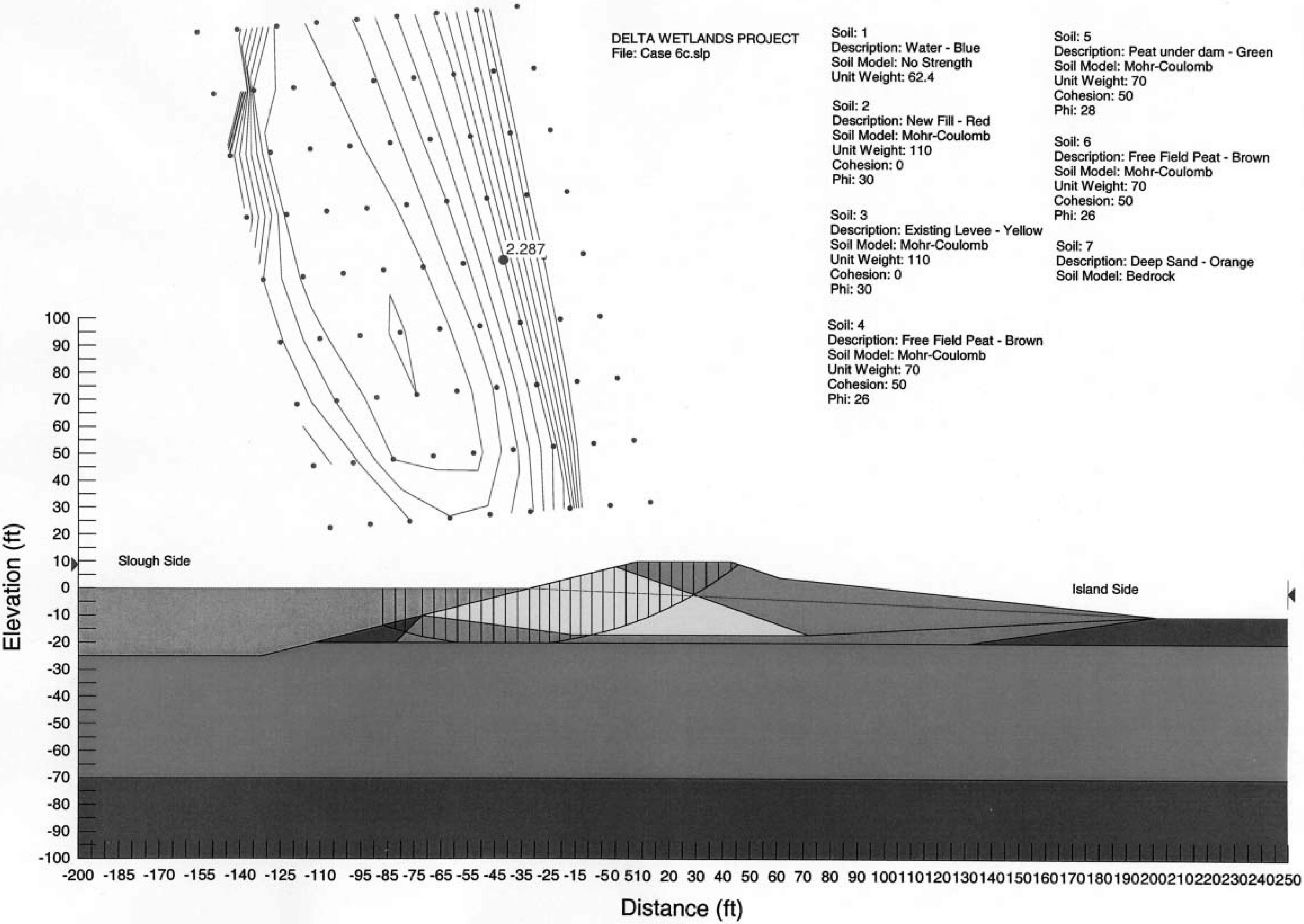

DELTA WETLANDS PROJECT
File: Case 6A.slp
2.341
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)

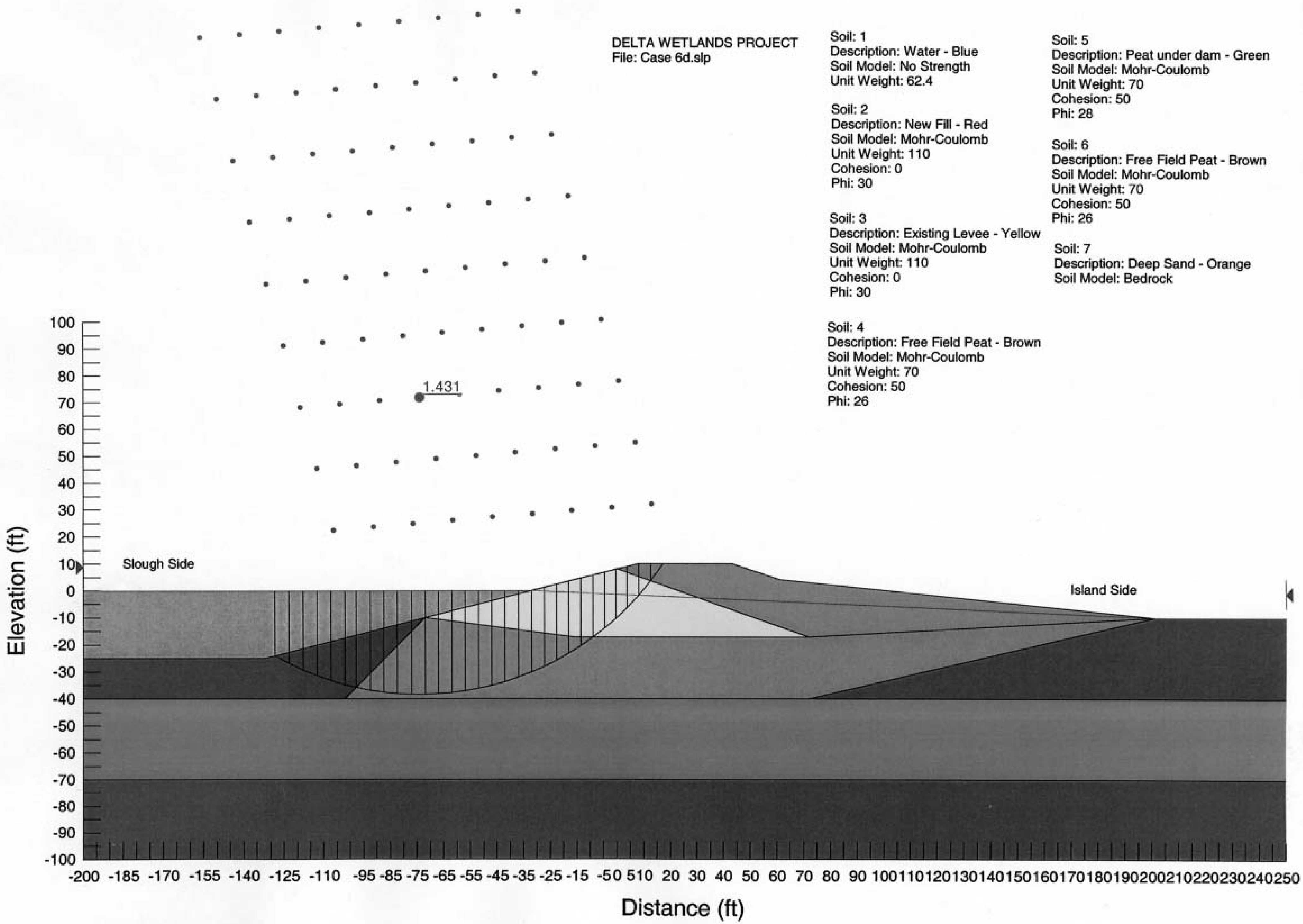

DELTA WETLANDS PROJECT
File: Case 6B.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.393
Slough Side
Island Side
Elevation (ft)
Distance (ft)

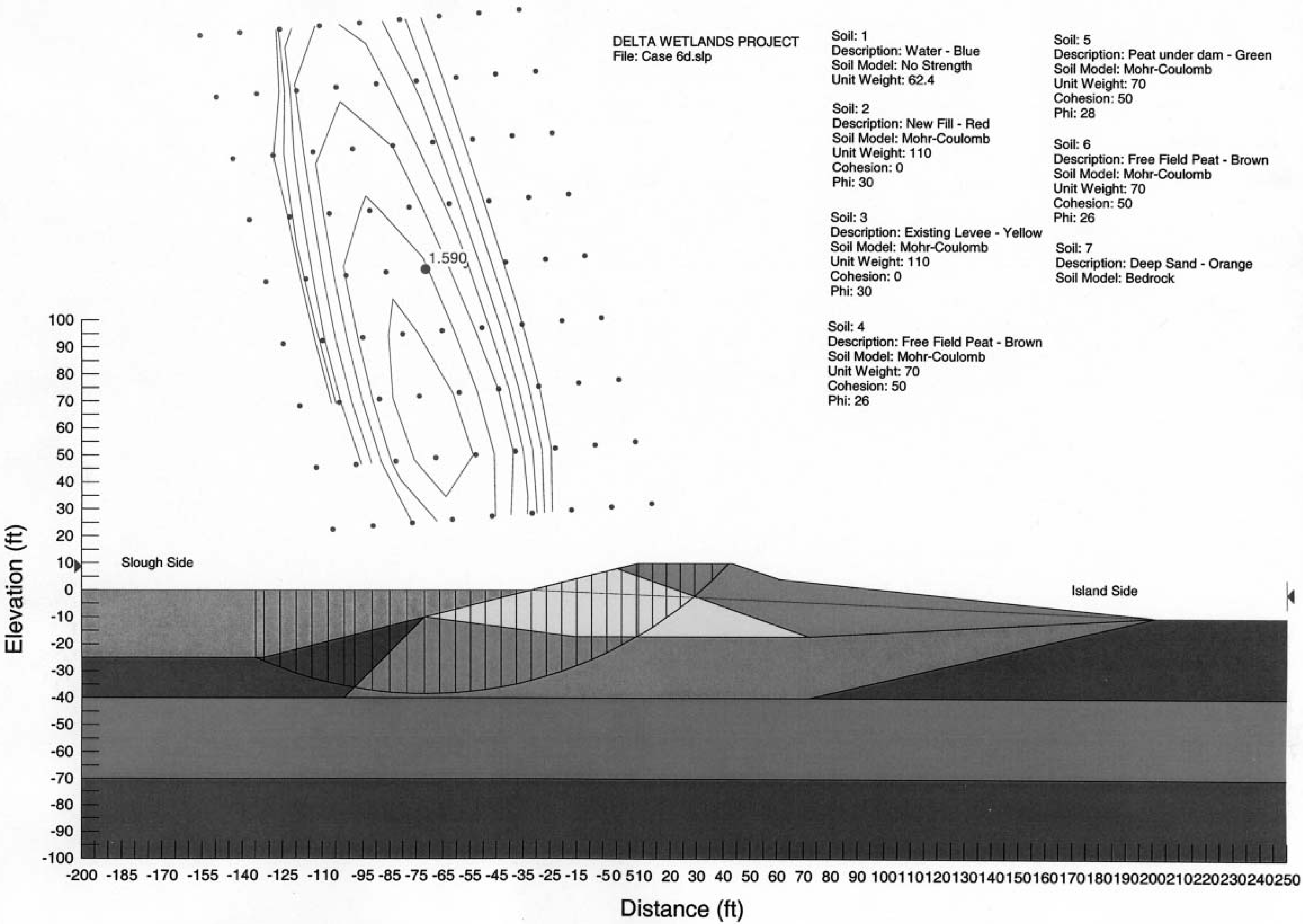

DELTA WETLANDS PROJECT
File: Case 6B.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.641
Slough Side
Island Side
Elevation (ft)
Distance (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200



DELTA WETLANDS PROJECT
File: Case 6c.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.729
Slough Side
Island Side
Elevation (ft)
Distance (ft)


DELTA WETLANDS PROJECT
File: Case 6c.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
2.287
Slough Side
Island Side
Elevation (ft)
Distance (ft)


DELTA WETLANDS PROJECT
File: Case 6d.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.431
Slough Side
Island Side
Elevation (ft)
Distance (ft)



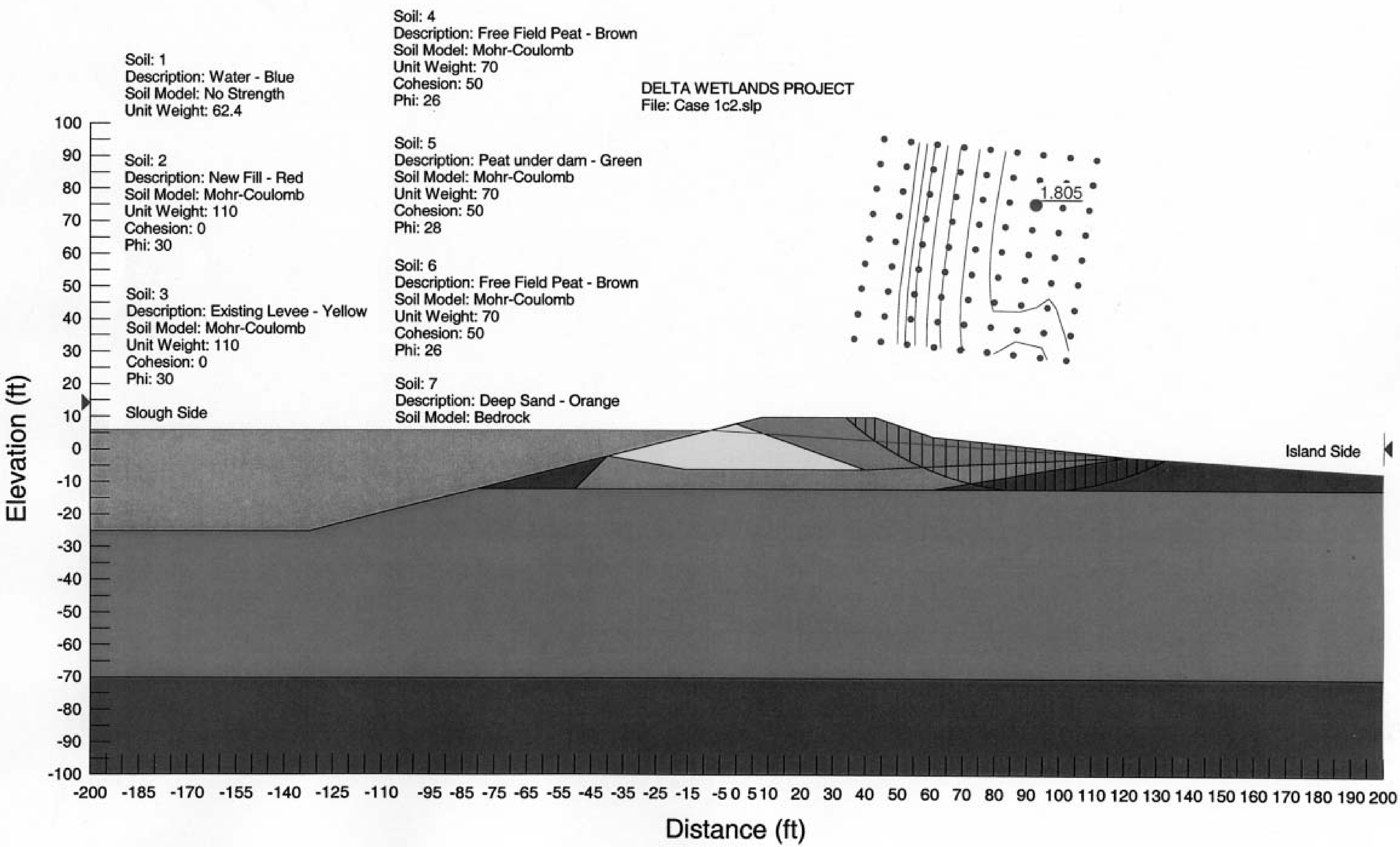
DELTA WETLANDS PROJECT
File: Case 6d.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.590
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Distance (ft)

c. Steady-state Condition with Sliding Towards the Island Side. - The analyses performed to date for levees and for a storage reservoir indicate that slopes on the island side need to be 5:1 or flatter or be 3:1 with a buttressing berm. A continuous slope such as 5:1 general requires a greater volume of material so a steeper slope with a buttressing berm is generally more economical as illustrated on figure x. Actual slopes should be based upon economics (quantity of fill required), staged construction requirements, and achieving a factor of safety of approximately 1.5. Based on previous analyses and some additional analyses, as shown on Table x, DWR/BOR recommends that at this level of study a slope of 3:1 down to elevation 4 and a slope of 10:1 below that elevation should be used. More complete analysis should be done during final design to optimize slopes for different reaches of the embankments with different geometry and foundation conditions.

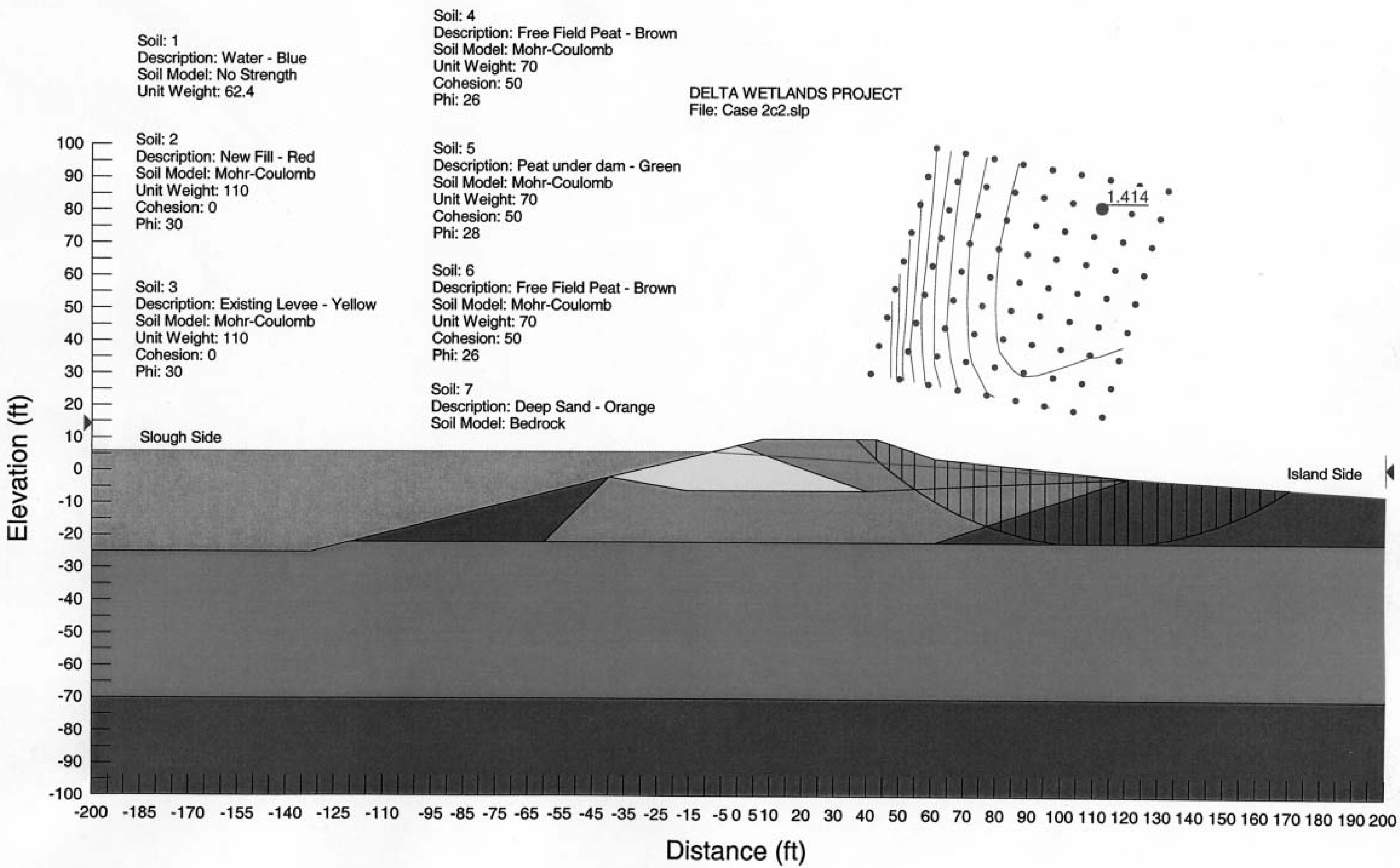
Table x. DWR/BOR Factors of Safety for Steady-state Condition and Sliding Towards Island

	1	2	3	4	5	6	7	8
Height of Existing Embankment, feet	10	10	10	24	24	24	16	16
Thickness of peat, feet	10	20	40	10	20	40	20	30
New Crest Elevation	10	10	10	10	10	10	15	15
Factor of Safety	1.80	1.41	1.26	2.71	1.96	1.49	1.67	1.46

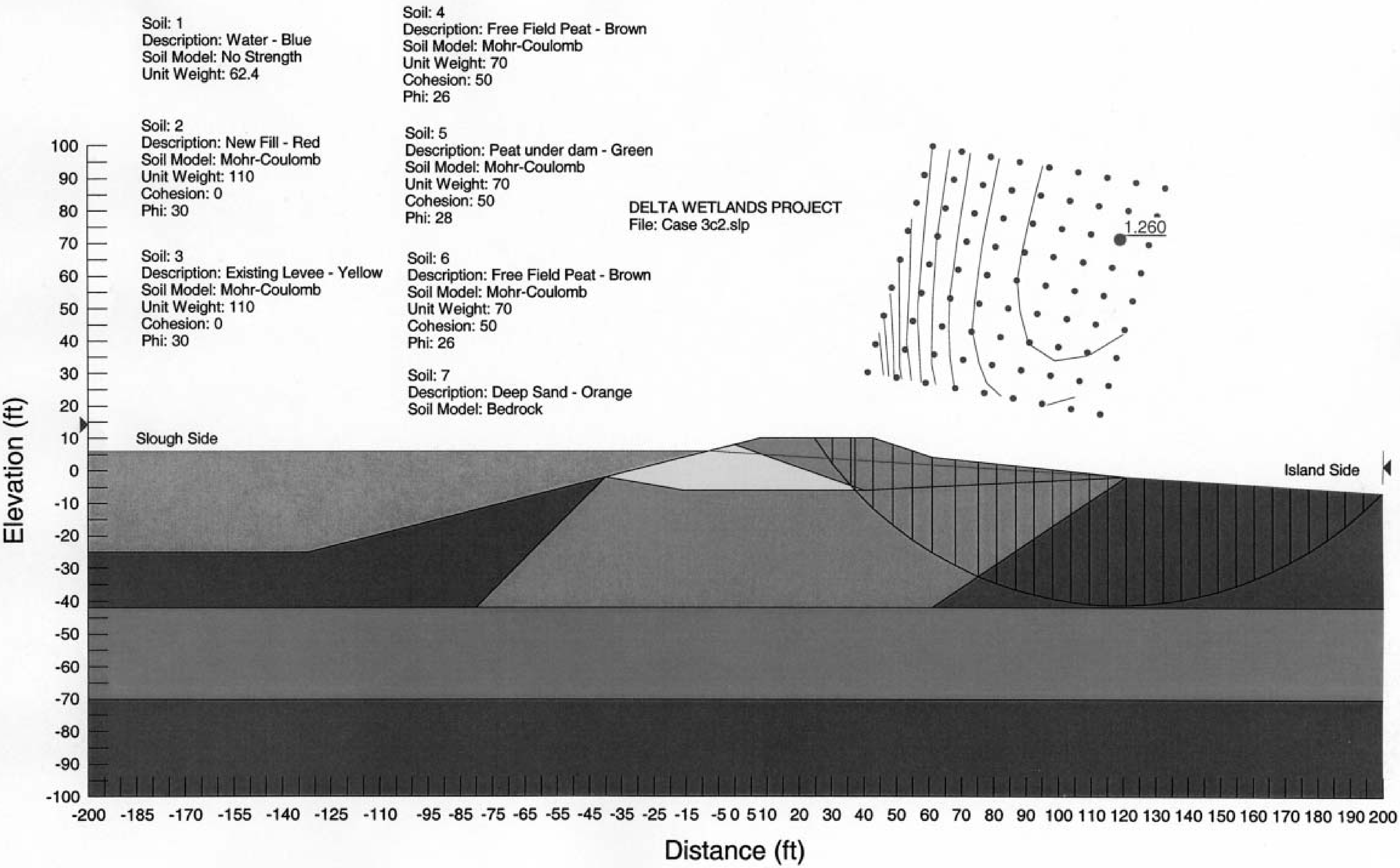
Assumes existing slope is approximately 4:1, new slope is 3:1 to elevation 4 and then 10:1, slough side slope is cut back to 4:1, and a new crest width of 35 feet, reservoir empty and river at elevation 6

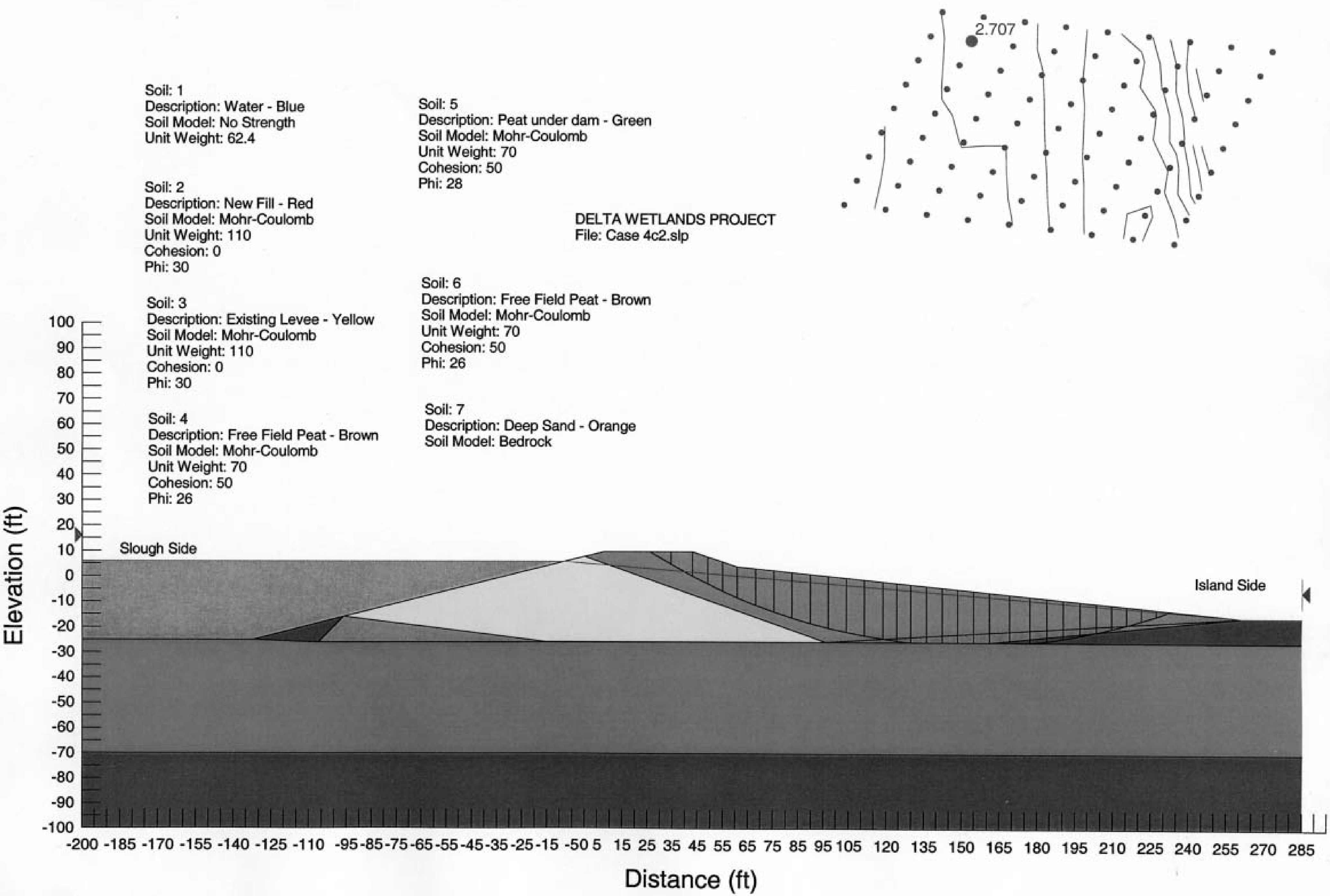


Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Slough Side
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 1c2.slp
1.805
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)

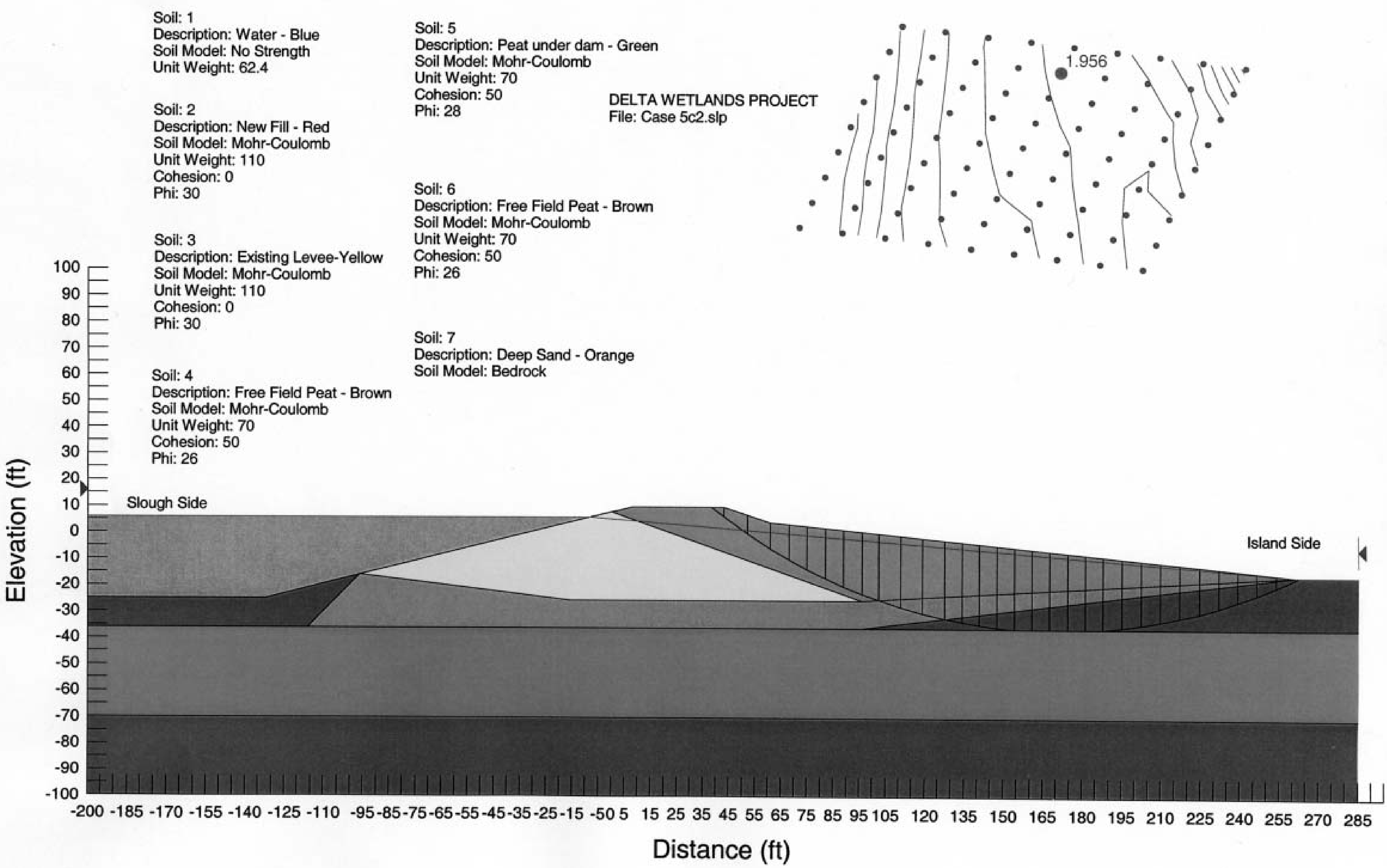


Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 2c2.slp
1.414
Slough Side
Island Side
Elevation (ft)
Distance (ft)

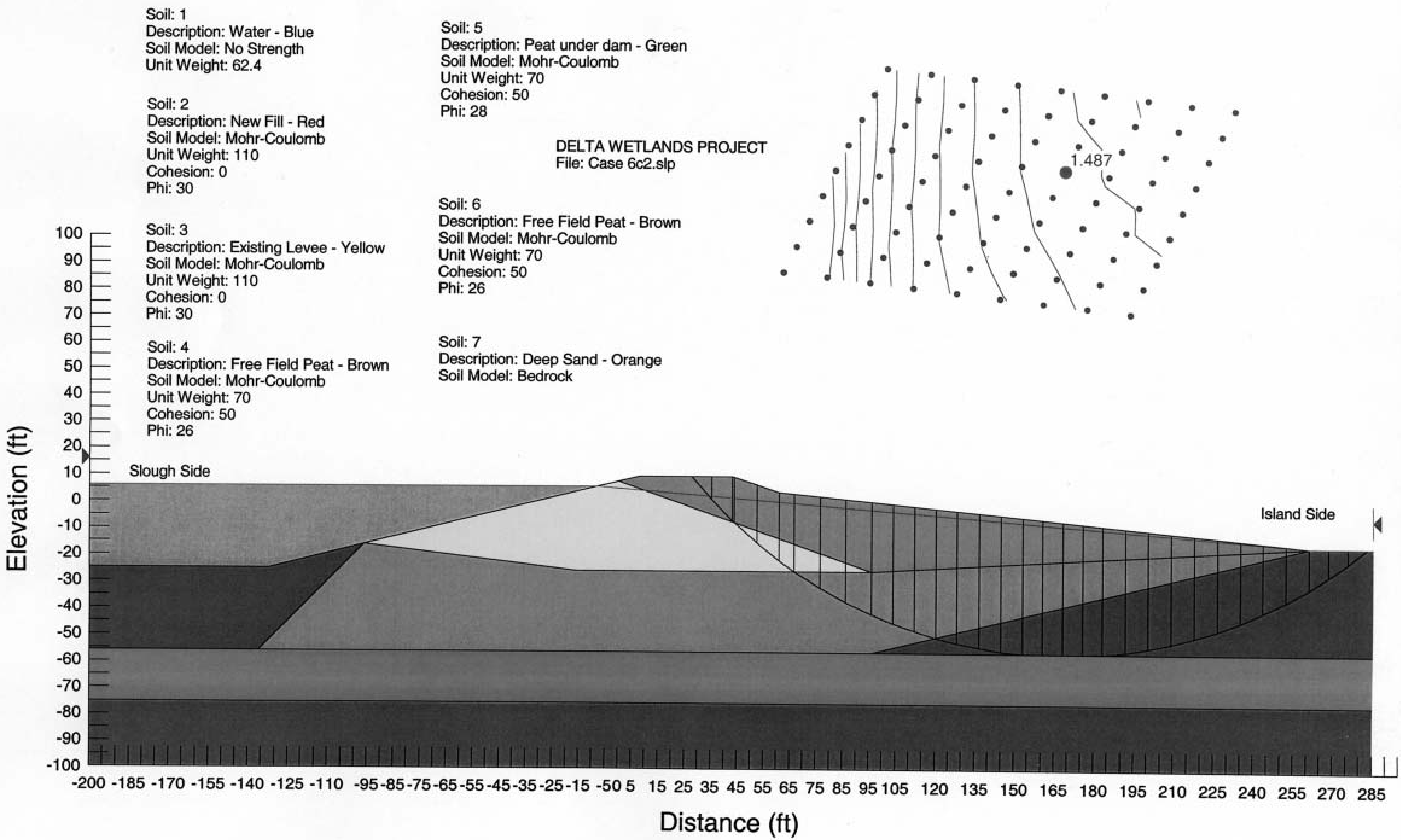

Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 3c2.slp
1.260
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)



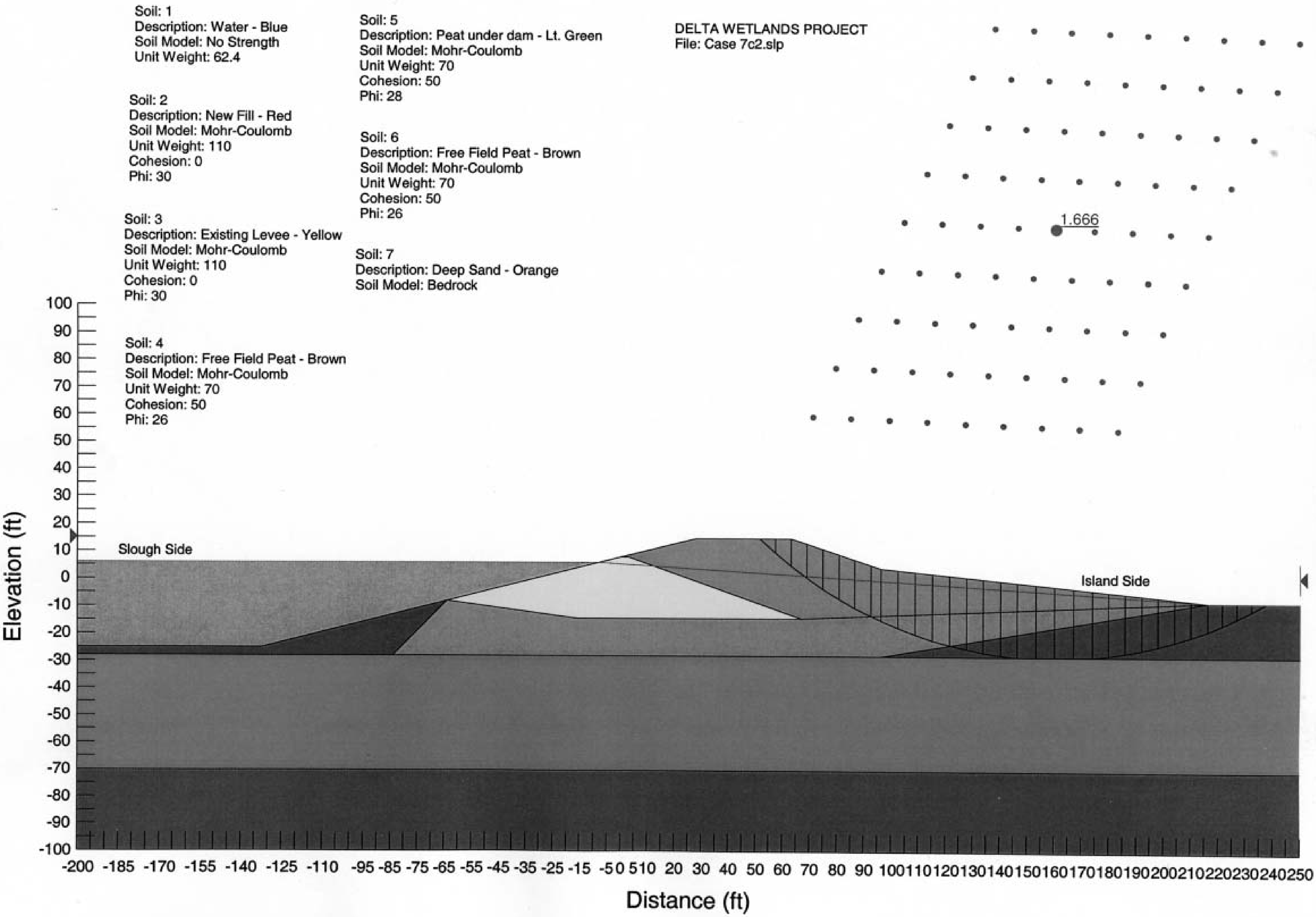
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 4c2.slp
2.707
Slough Side
Island Side
Elevation (ft)
100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)



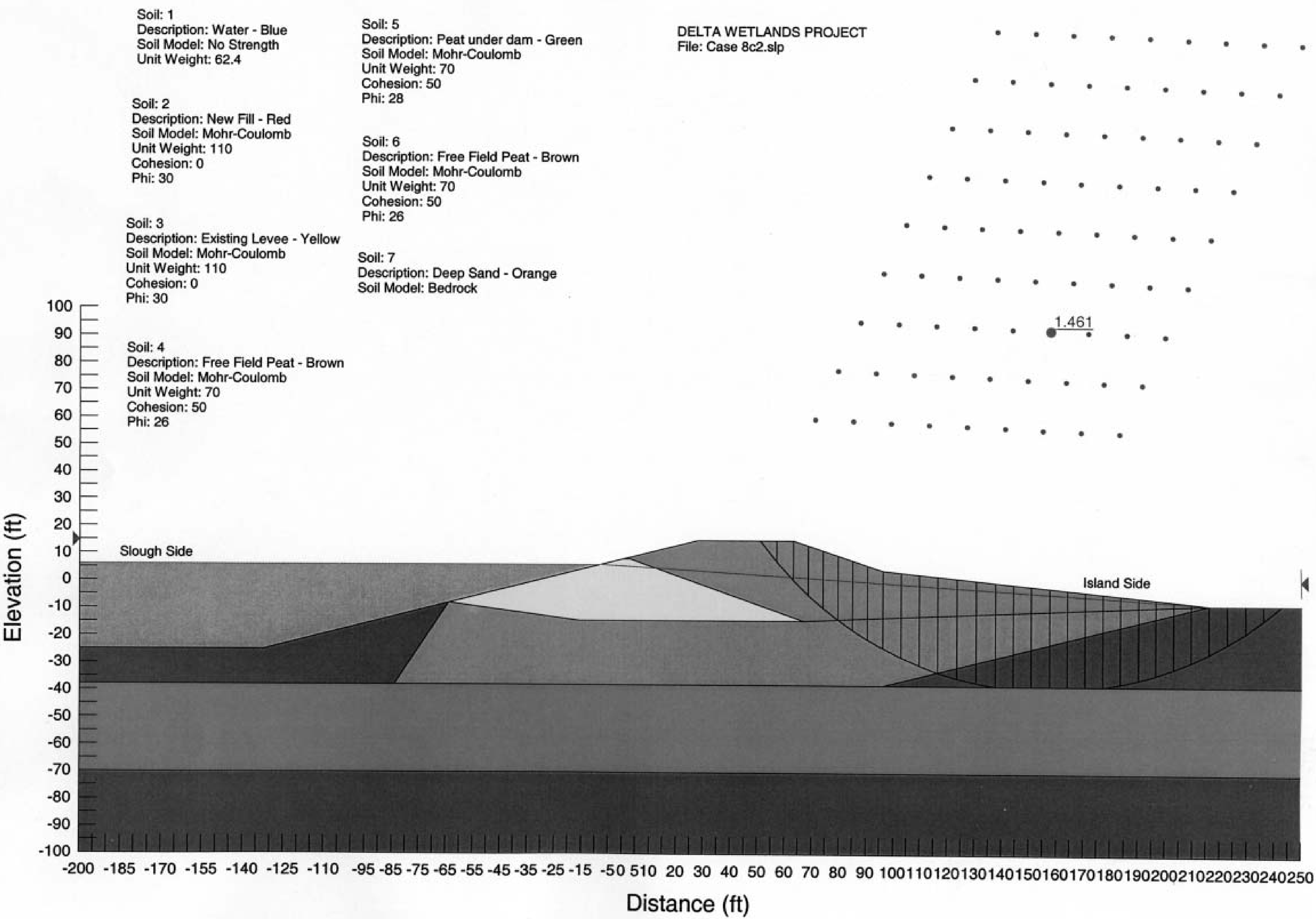
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee-Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 5c2.slp
1.956
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -50 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)



Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
DELTA WETLANDS PROJECT
File: Case 6c2.slp
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
1.487
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -50 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)



Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Lt. Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 7c2.slp
1.666
Slough Side
Island Side
Elevation (ft)
Distance (ft)



Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 8c2.slp
1.461
Slough Side
Island Side
Elevation (ft)
Distance (ft)

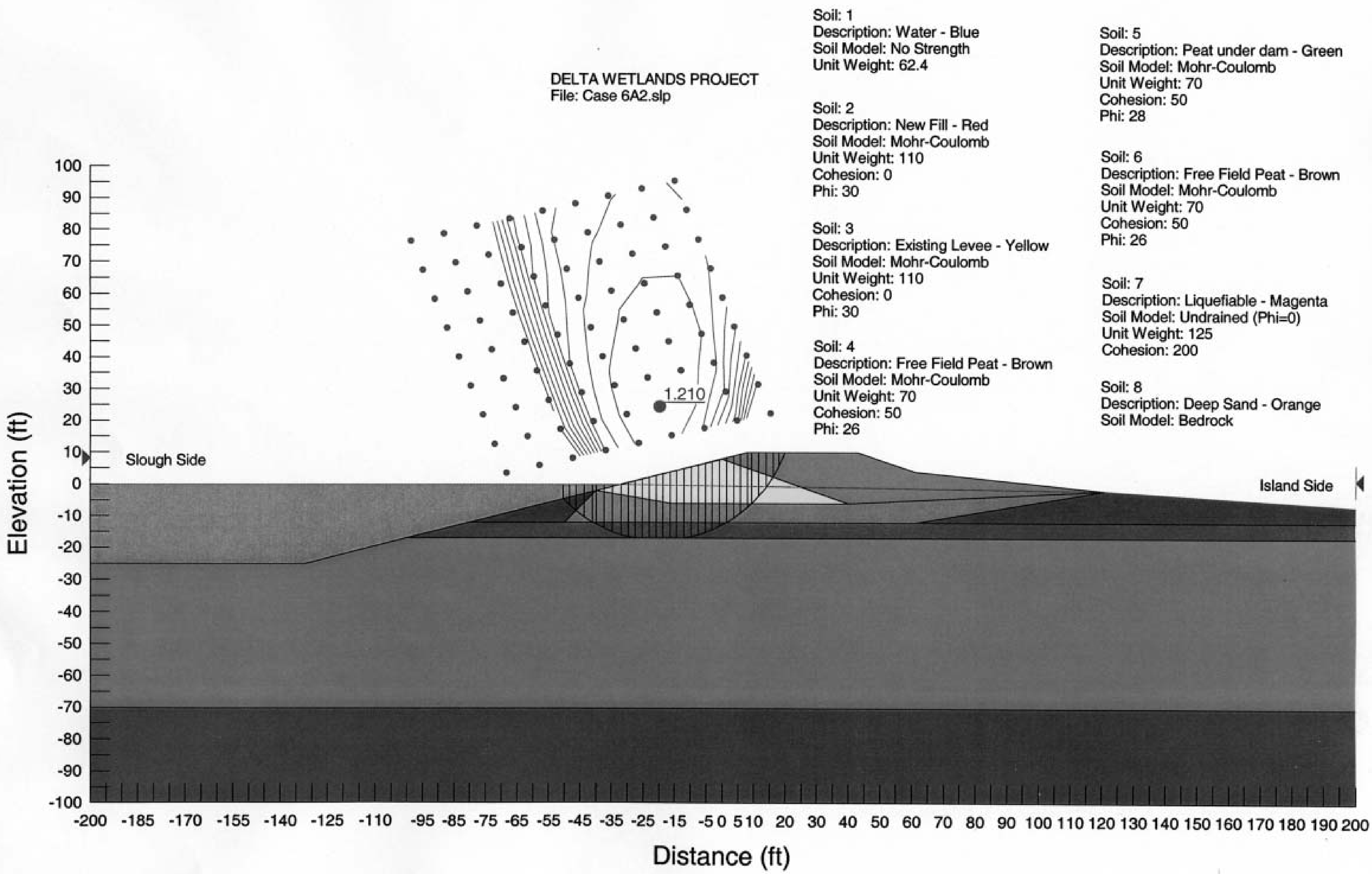
4.3.5 Post-liquefaction Stability Analysis

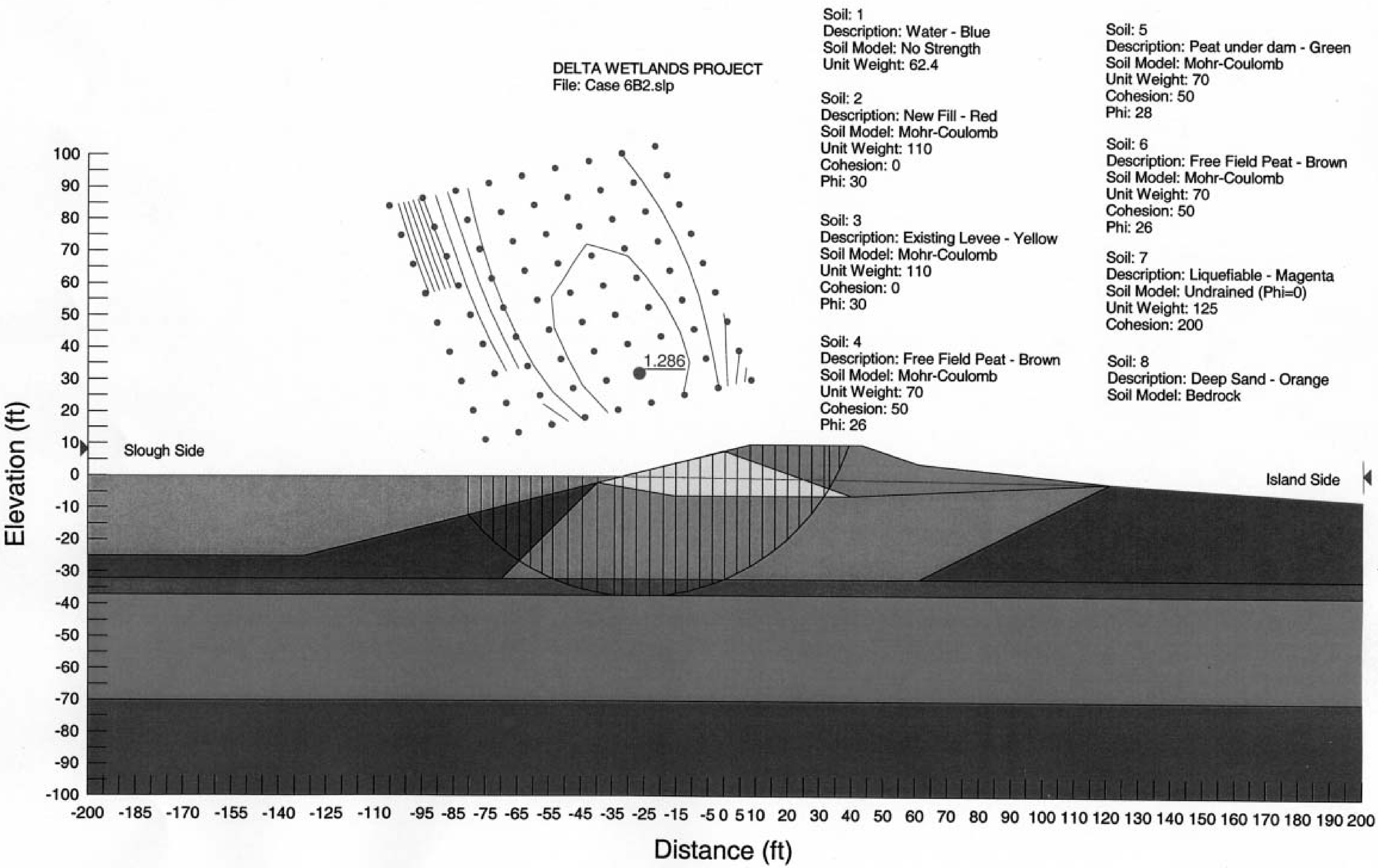
A post liquefaction analysis was performed on the same sections used for the steady-state analysis. Liquefied strengths of a small layer of material at the top of the sand layer was assumed to be 100, 200 and 400 psf. No other strength reductions were assumed. As shown in table x for sliding towards the river/slough if the liquefied strength is at least 200 psf a post-liquefaction sliding failure will not occur. As shown in table y for sliding towards the island if the liquefied strength is at least 200 psf a post-liquefaction sliding failure will probably not occur. During final design an in-depth analysis of the SPT data should be done to verify that the minimum liquefied strength is 200 psf. Future analyses should also evaluate the potential loss of strength in the peat material due to straining beyond the fiber bond strength.

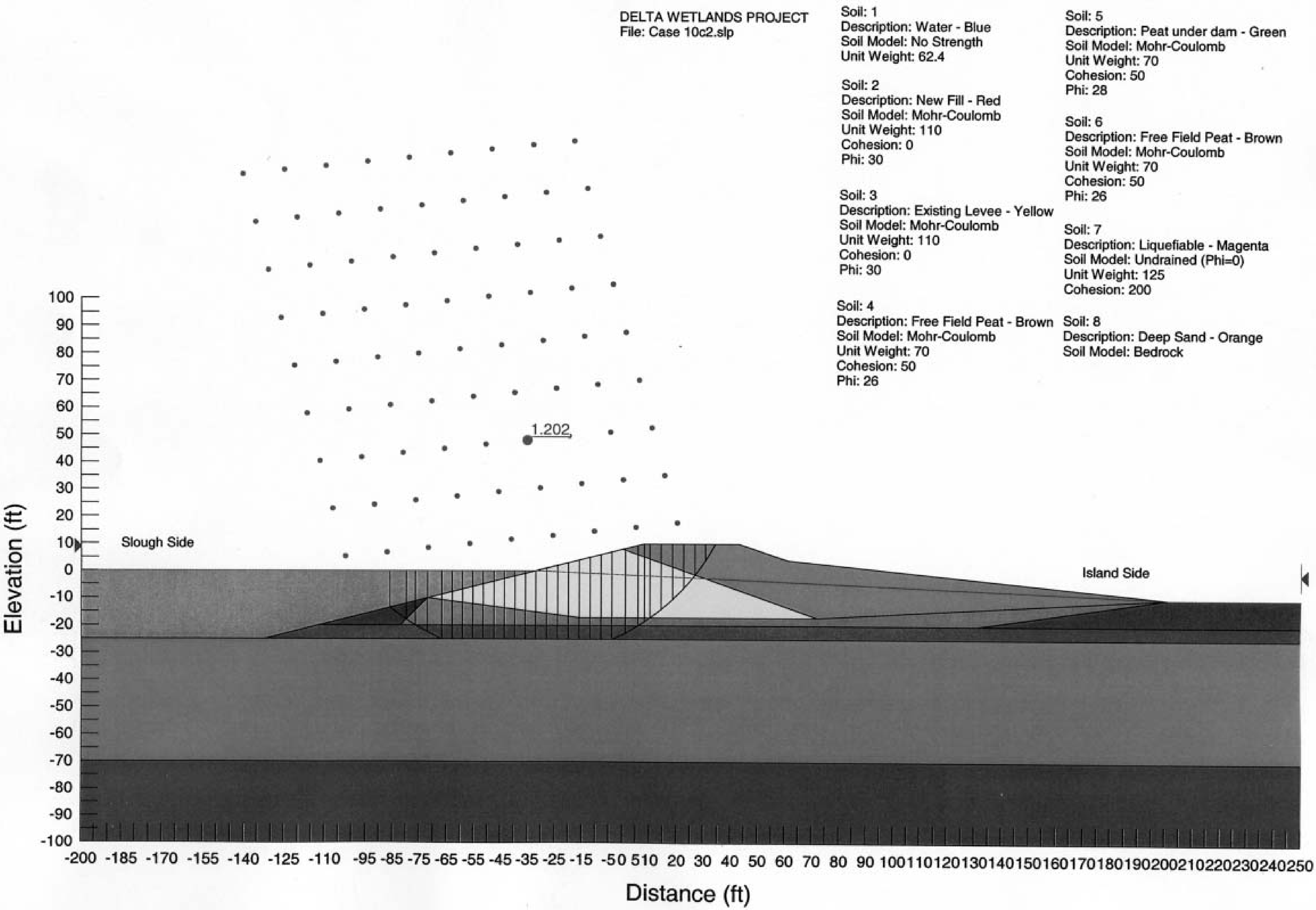
Table x. DWR/BOR Factors of Safety for Post Liquefaction Condition and Sliding Towards River/Slough

Liquefied Strength, psf	**Factor of Safety* 10' embankment**		**Factor of Safety* 18' embankment**	
	10' peat	30' peat	10' peat	30' peat
100	0.93	1.11	0.91	1.04
200	1.21	1.29	1.20	1.22
400	1.58	1.40	1.70	1.43
no liquef.	1.56	1.39	1.73	1.43

* Assumed 4:1 slope on the river/slough side, water in the slough to elevation 0 , no water in the reservoir, free field peat strength assumed to be c=50 psf and $\varphi = 26$, peat under embankment strength assumed to be c=50 psf and
$\varphi = 28$


DELTA WETLANDS PROJECT
File: Case 6A2.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
1.210
Slough Side
Island Side
Elevation (ft)
Distance (ft)


DELTA WETLANDS PROJECT
File: Case 6B2.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
1.286
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)



DELTA WETLANDS PROJECT
File: Case 10c2.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
1.202
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Distance (ft)

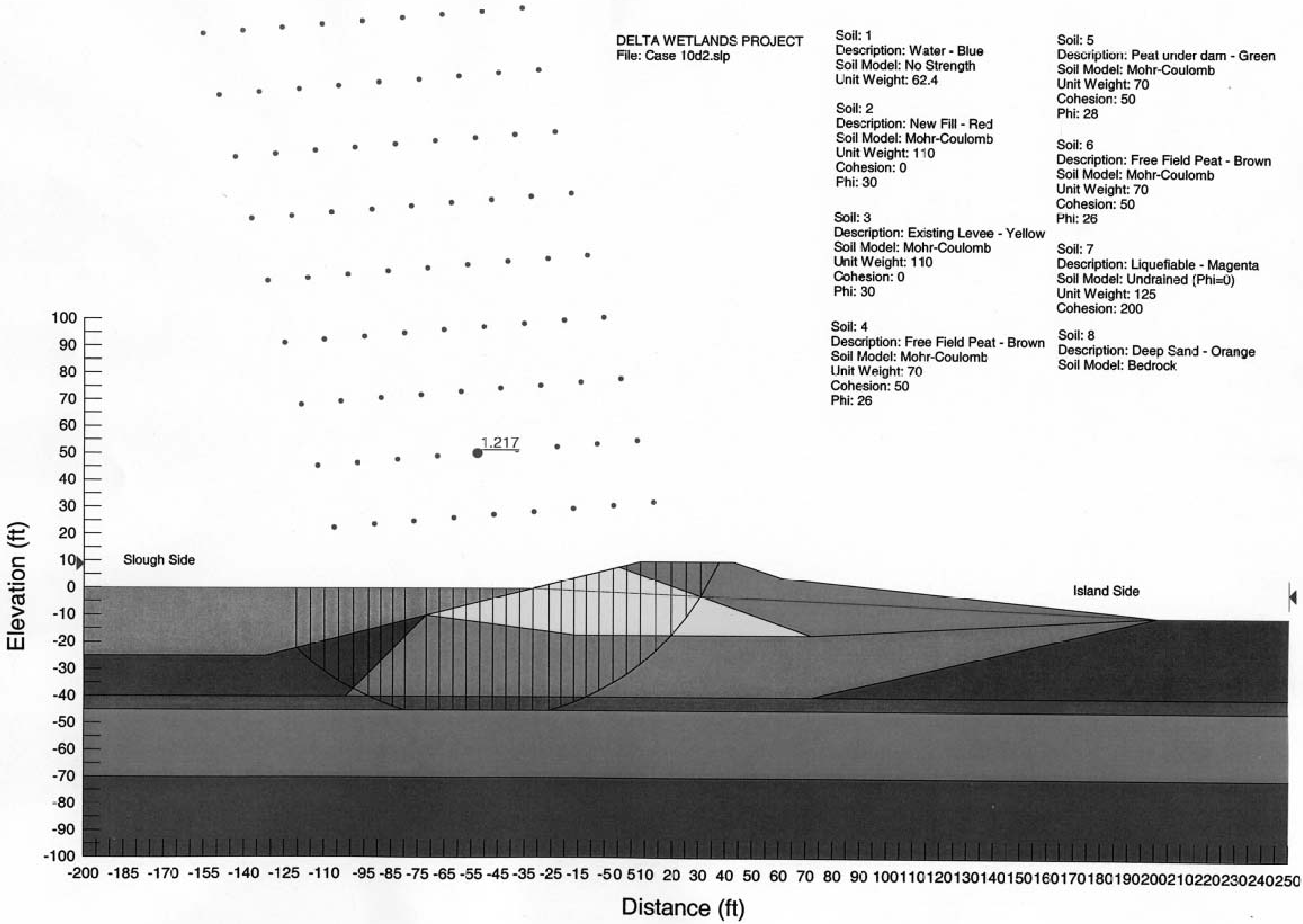
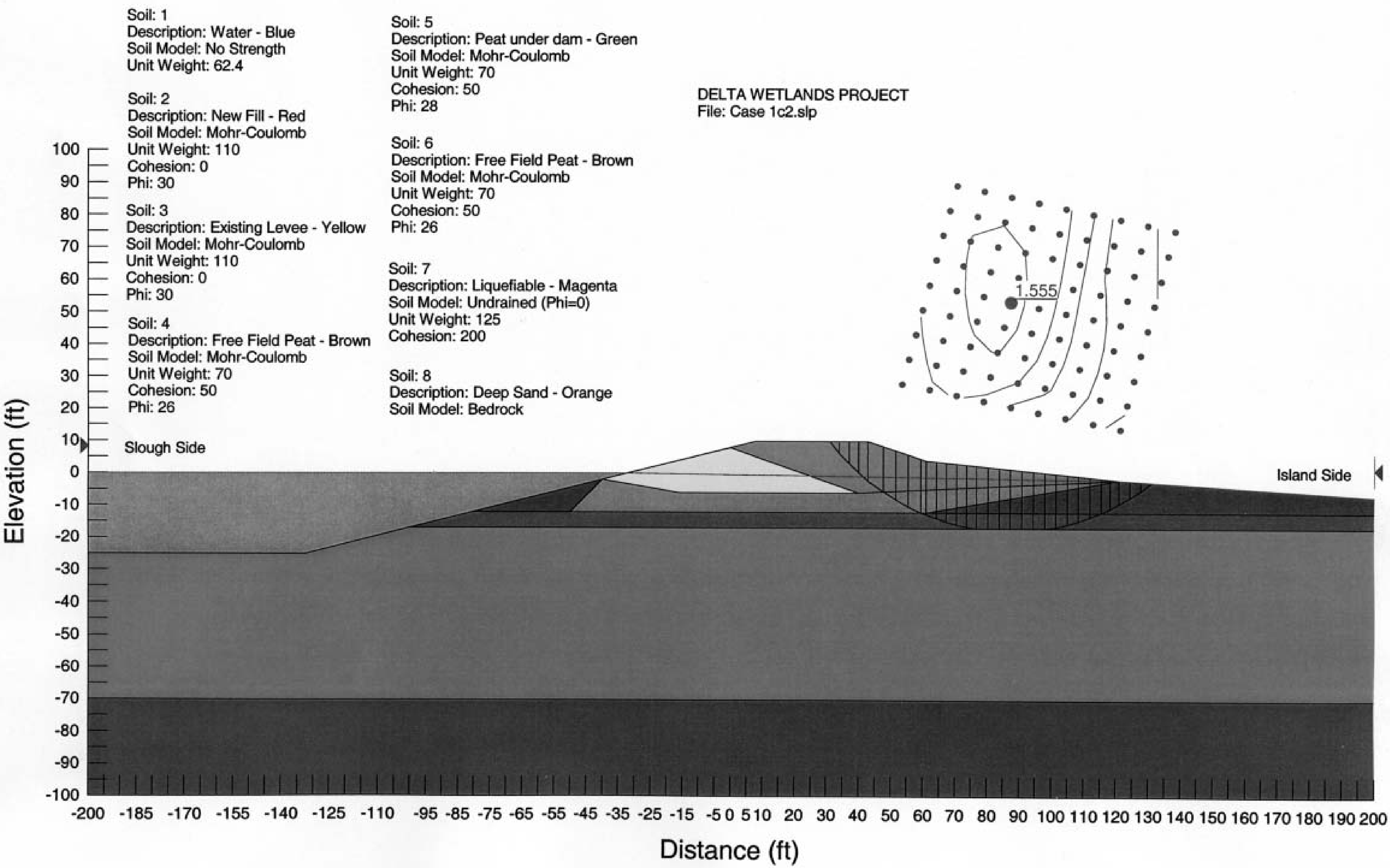

DELTA WETLANDS PROJECT
File: Case 10d2.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
1.217
Slough Side
Island Side
Elevation (ft)
Distance (ft)

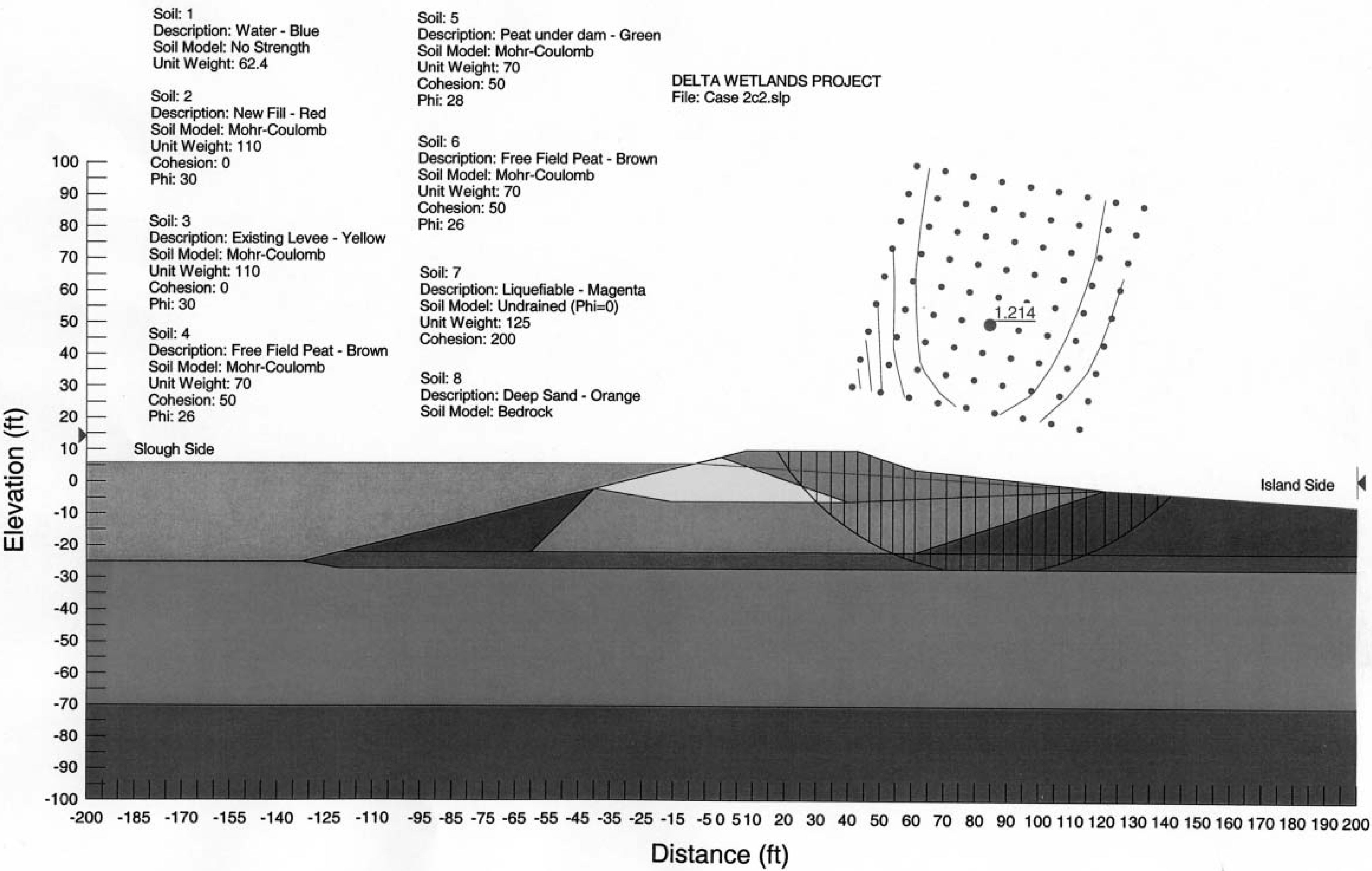
Table y. DWR/BOR Factors of Safety for Post Liquefaction Condition and Sliding Towards Island

	1	2	3	4	5	6	7	8
Height of Existing Embankment, feet	10	10	10	24	24	24	16	16
Thickness of peat, feet	10	20	40	10	20	40	20	30
New Crest Elevation	10	10	10	10	10	10	15	15
Factor of Safety- no liquef.	1.80	1.41	1.26	2.71	1.96	1.49	1.67	1.46
Factor of Safety for 100 psf	1.21	1.0	1.02	1.23	1.06	0.98	0.98	0.92
Factor of Safety for 200 psf	1.55	1.21	1.16	1.49	1.24	1.07	1.17	1.06
Factor of Safety for 400 psf	2.16	1.43	1.26	1.97	1.56	1.26	1.49	1.32

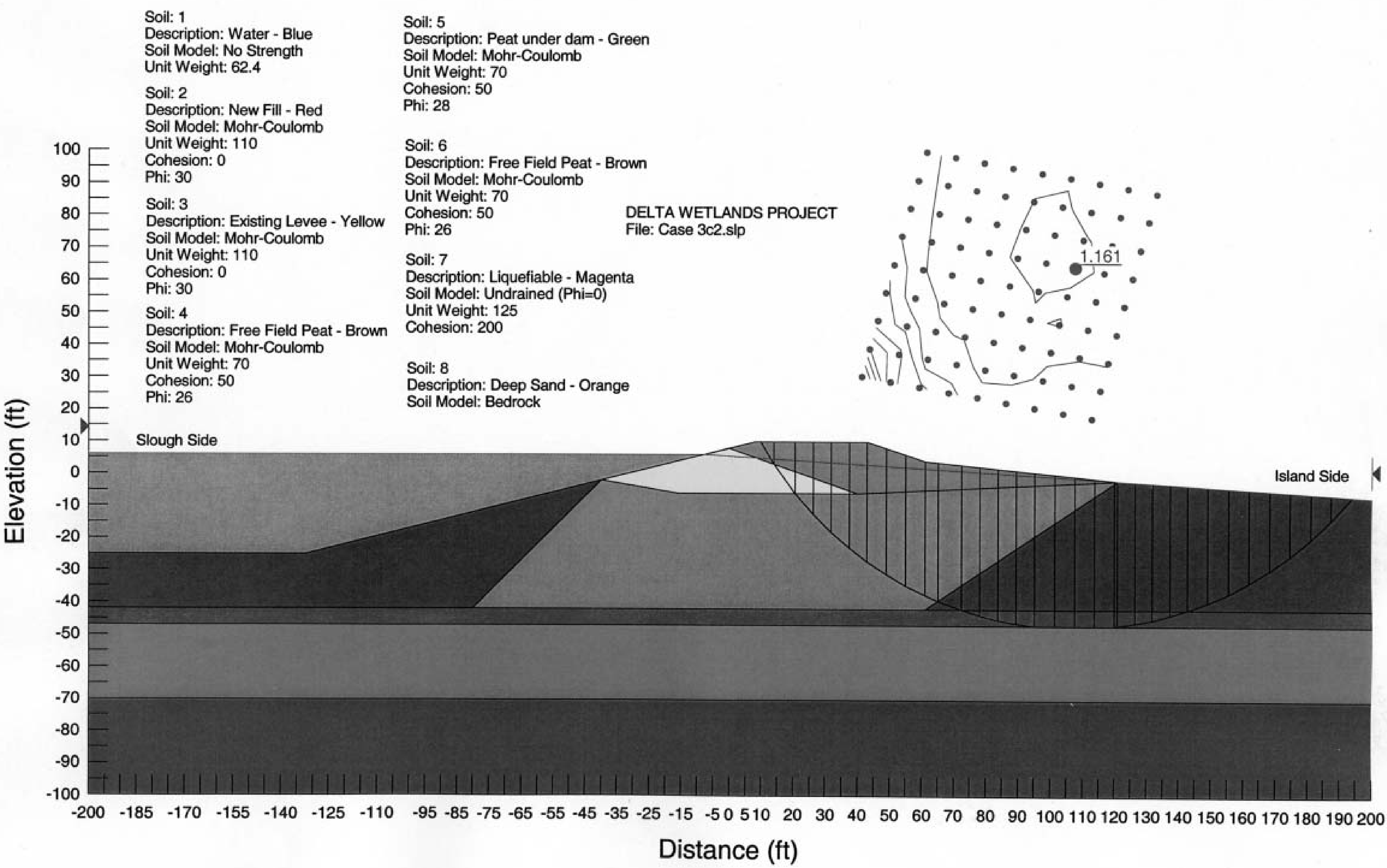
Assumes existing slope is approximately 4:1, new slope is 3:1 to elevation 4 and then 10:1, slough side slope is cut back to 4:1, and a new crest width of 35 feet, reservoir empty and river at elevation 6



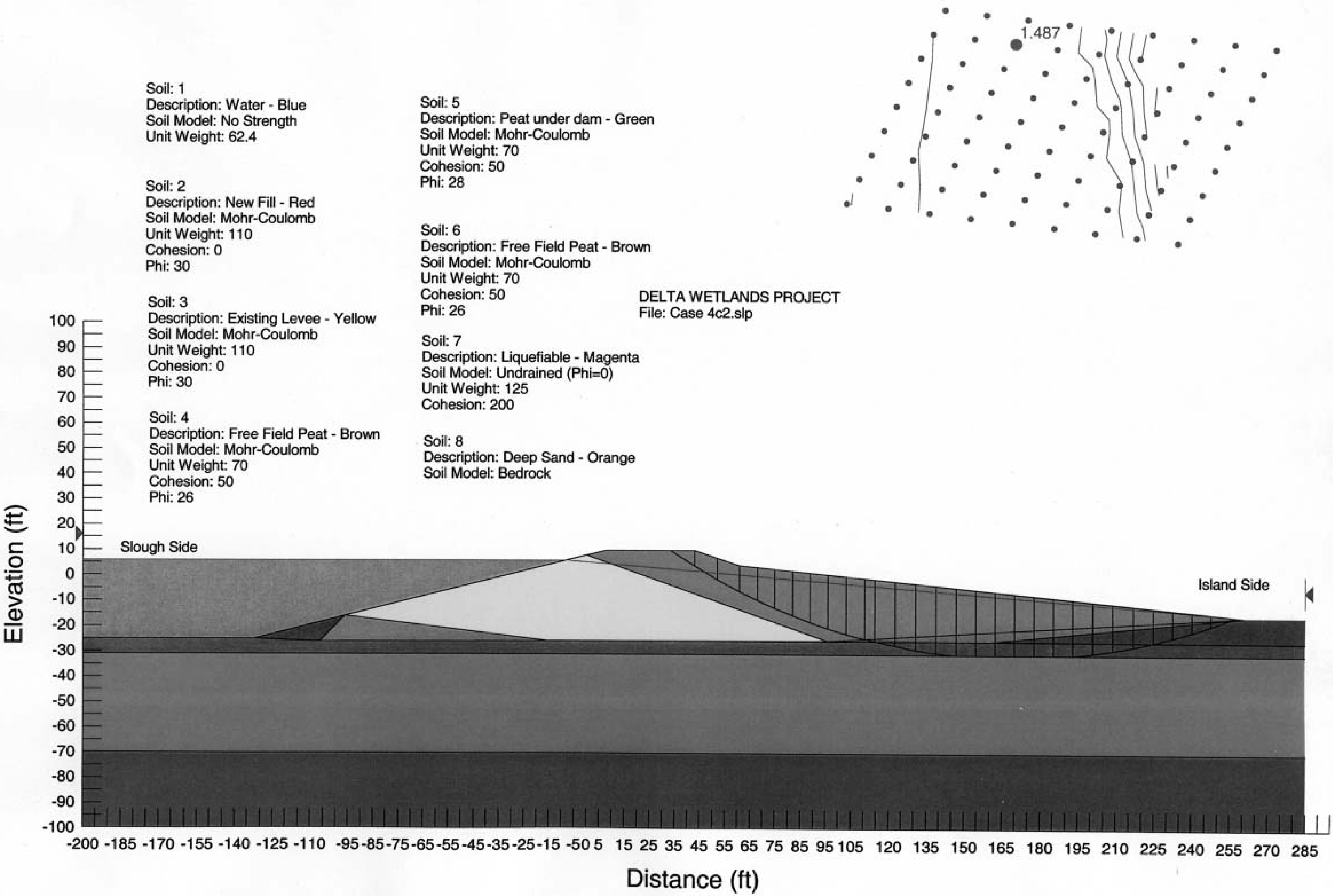
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 1c2.slp
1.555
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)



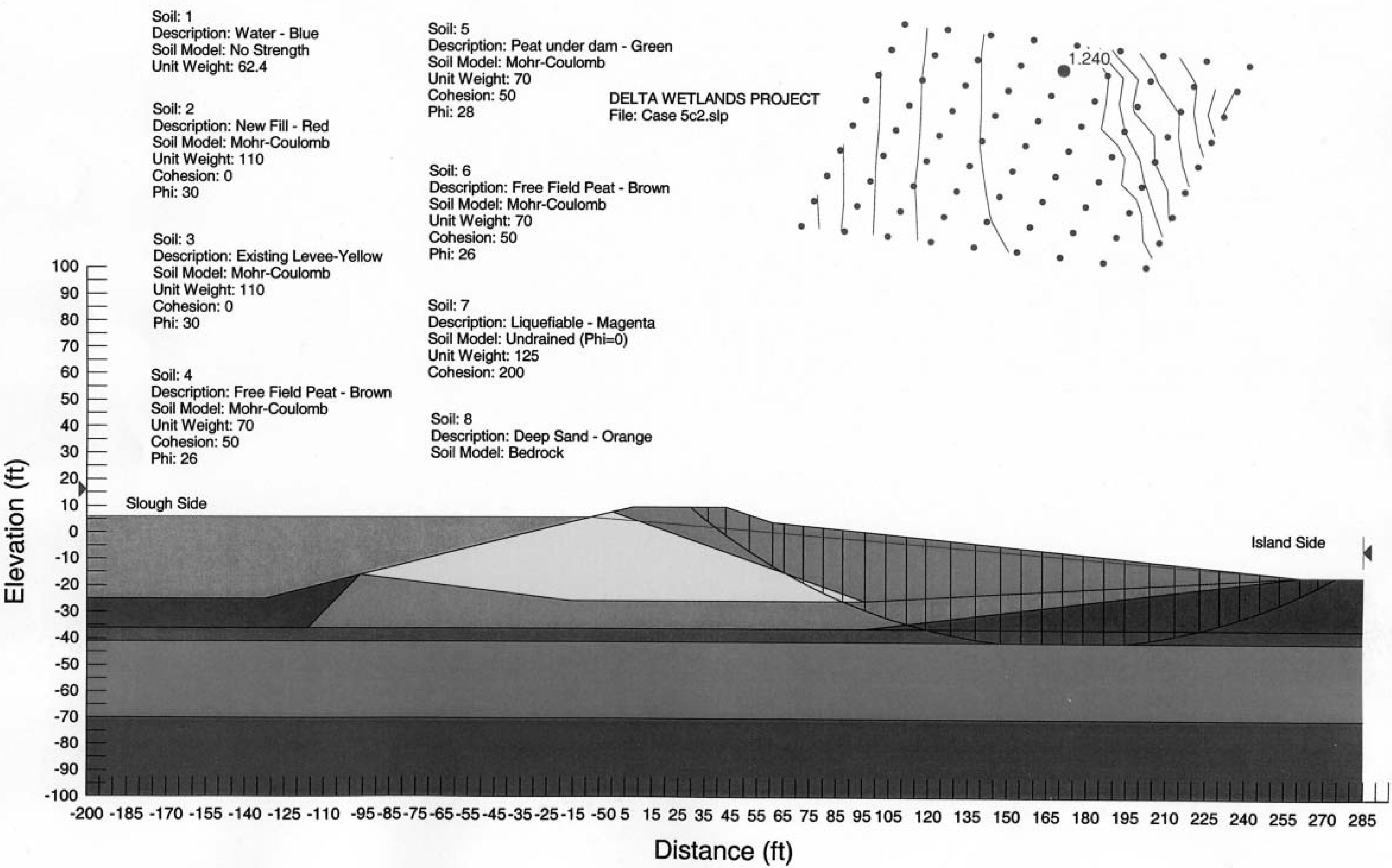
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 2c2.slp
1.214
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)

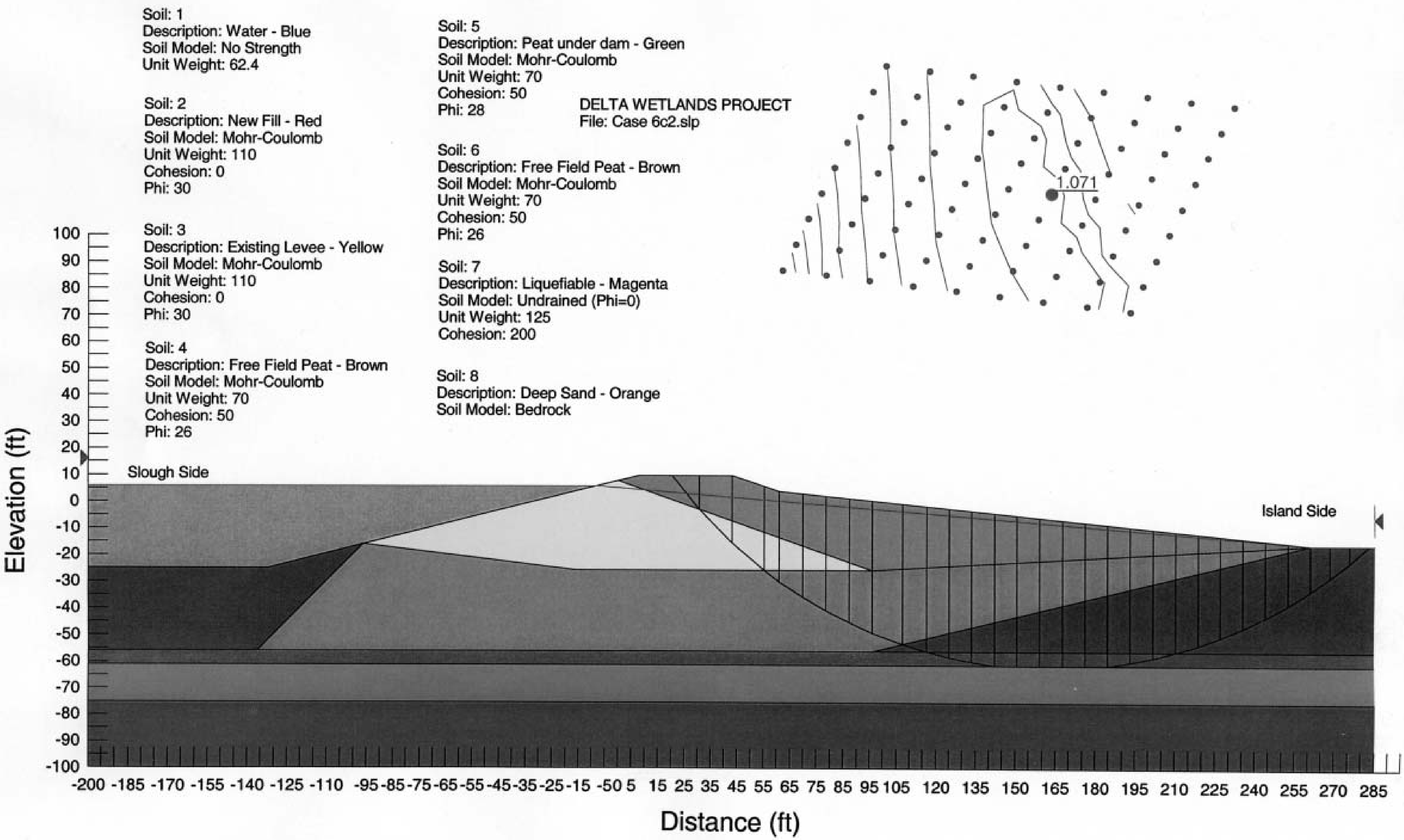


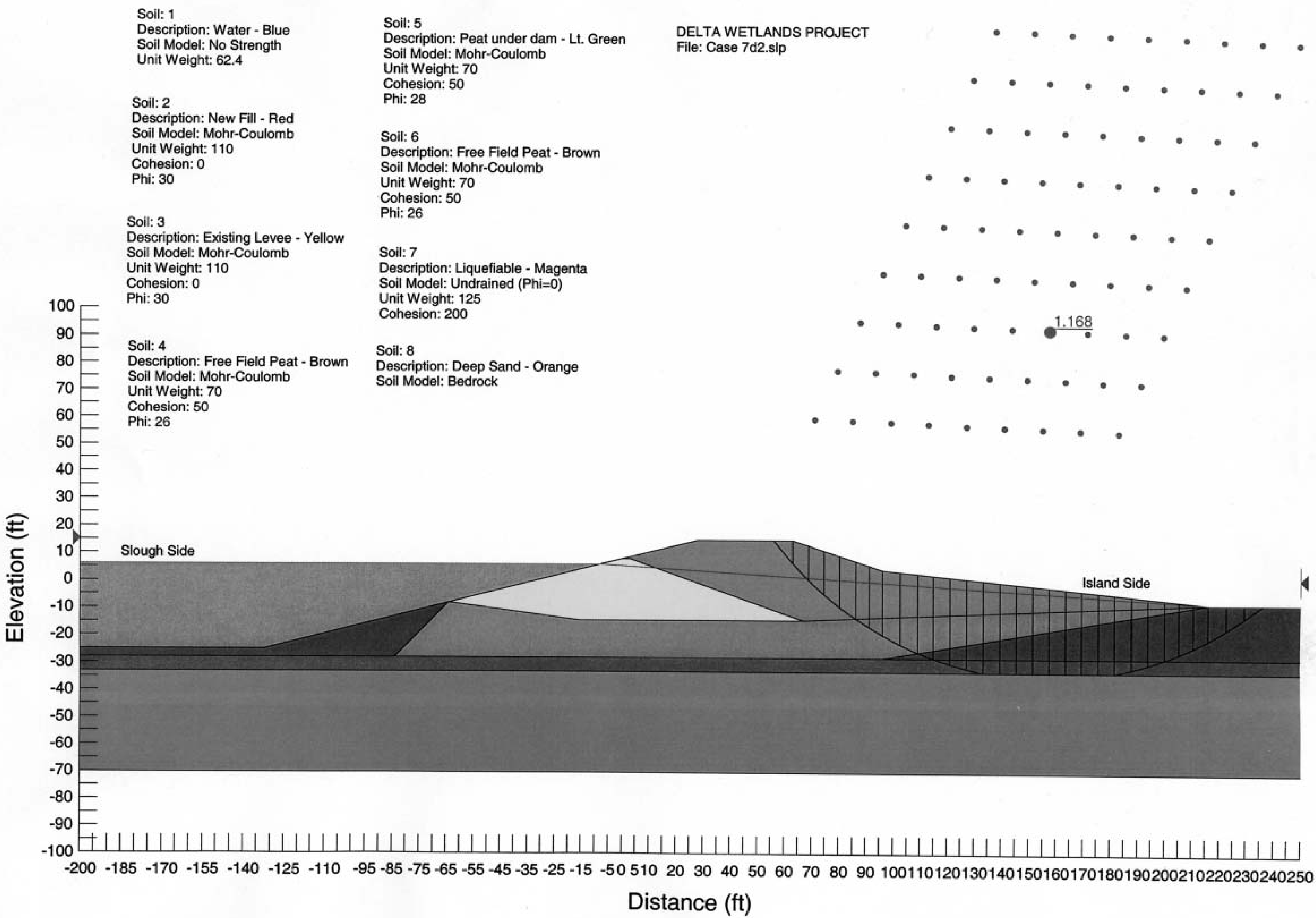
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 3c2.slp
1.161
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance (ft)



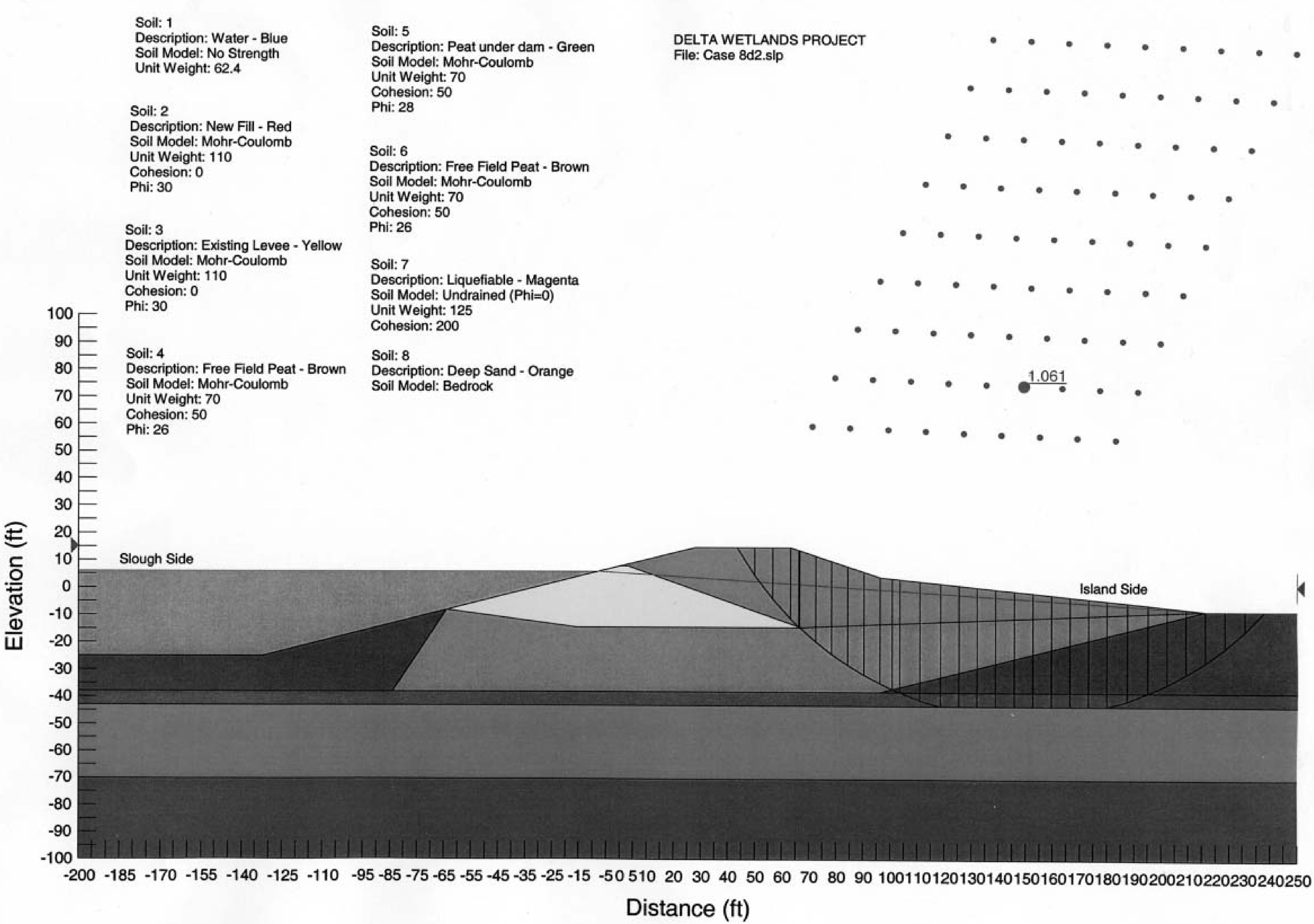
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 4c2.slp
1.487
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)


Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee-Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 5c2.slp
1.240
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)


Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 6c2.slp
1.071
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 15 25 35 45 55 65 75 85 95 105 120 135 150 165 180 195 210 225 240 255 270 285
Distance (ft)



Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Lt. Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
DELTA WETLANDS PROJECT
File: Case 7d2.slp
1.168
Slough Side
Island Side
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200 -185 -170 -155 -140 -125 -110 -95 -85 -75 -65 -55 -45 -35 -25 -15 -5 0 5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Distance (ft)



DELTA WETLANDS PROJECT
File: Case 8d2.slp
Soil: 1
Description: Water - Blue
Soil Model: No Strength
Unit Weight: 62.4
Soil: 2
Description: New Fill - Red
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 3
Description: Existing Levee - Yellow
Soil Model: Mohr-Coulomb
Unit Weight: 110
Cohesion: 0
Phi: 30
Soil: 4
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 5
Description: Peat under dam - Green
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 28
Soil: 6
Description: Free Field Peat - Brown
Soil Model: Mohr-Coulomb
Unit Weight: 70
Cohesion: 50
Phi: 26
Soil: 7
Description: Liquefiable - Magenta
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 200
Soil: 8
Description: Deep Sand - Orange
Soil Model: Bedrock
1.061
Slough Side
Island Side
Elevation (ft)
Distance (ft)